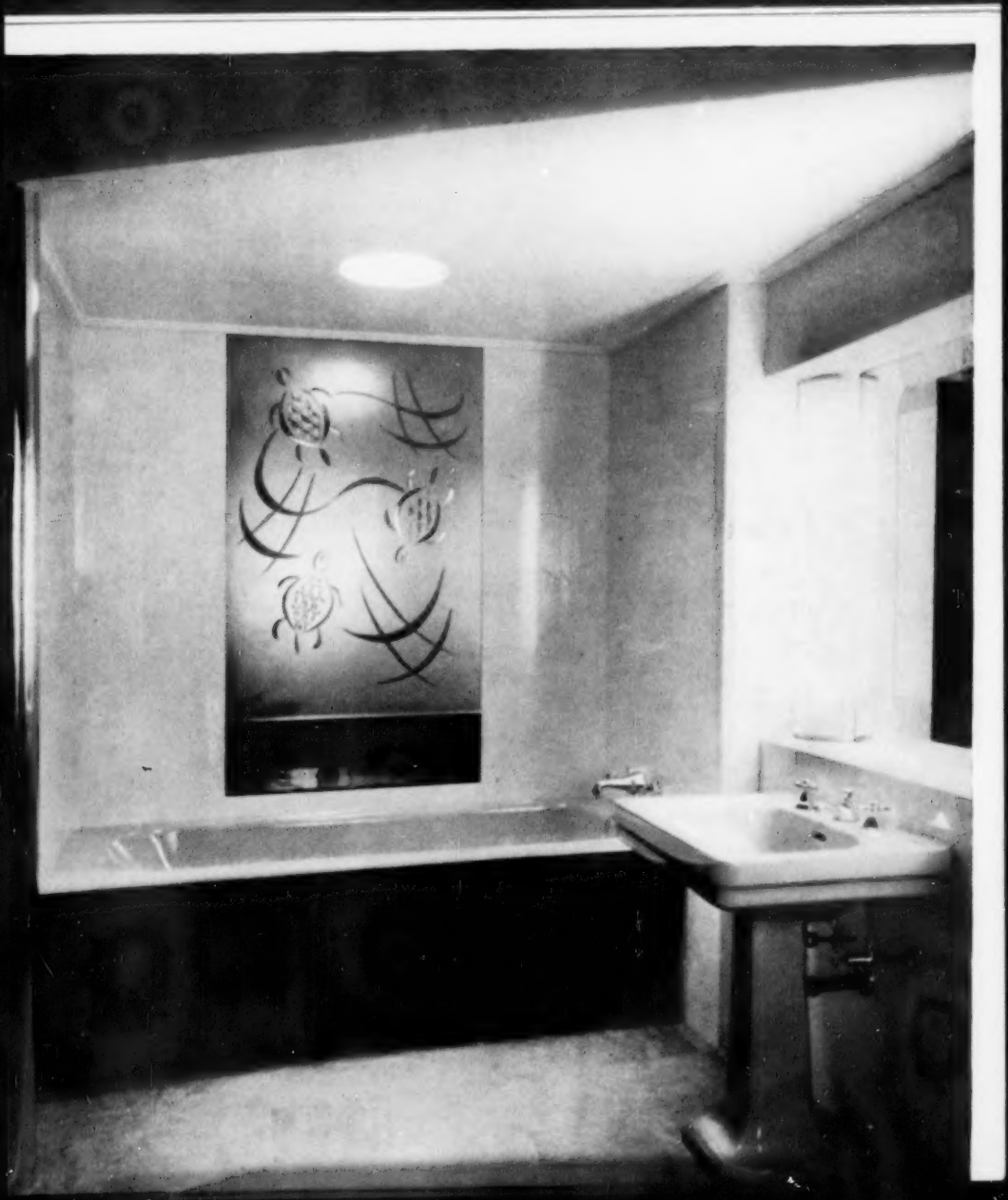
CERAMICS



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Ceramics

VOL. II MAY, 1950 NO. 15

British Ceramic Society Jubilee

THE mid-century has given us the years outstanding function in technology. The importance of the ceramic industry is undisputed but to those who organised this exhibition with such meticulous care the industry must offer its sincere thanks—preferably in tangible form.

The City of Stoke rose to the occasion with that display of hospitality, cultural background and sound technical reasoning realised only by those fortunate enough to meet the great people of North Staffordshire.

The exhibition of contemporary pottery in Hanley would have taken pride of place at any Exhibition in the world. Londoners would have heralded it with a literal fanfare of trumpets—but not the Potteries. The goods were presented with a quiet dignity by those who knew that they were masters of their craft. A pity indeed that Britishers at home under the age of 25 think of British Pottery as station buffet utensils—chipped, tea bespattered with someone else's mouthing or fabricated from some unbreakable but unliving thing called melamine!

Usually the platforms at affairs like this scintillate with Cabinet Ministers and politicians. These were conspicuous by their absence for folks came to see and discuss things—not platitudes.

The technical papers covered the 50 years progress in the industry. They showed that in spite of two major wars and a monthly succession of economic crises, those areas of Britain where man applies labour to raw materials to produce the wealth which the Whitehall-minded politicians dispense so light-heartedly get on with the job.

May the next 50 years bring prosperity and happiness to an industry which ensures that "in some corner of a foreign land, there is forever England."

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Matters of the Moment

• *by Argus* •

A REPORT of the British Ceramic Society's Jubilee meeting appears on another page, and readers will note that many professional societies could take advantage of the manner in which this was run, whereby social, technical and cultural activities were delightfully blended together.

The high spot I think was the pottery exhibition in the Victoria Hall, Hanley. Maybe to the residents of the Potteries it appeared mundane. You are used to, and take for granted the beauteous craft which reflects your industry. But I assure you that even at home in the provincial cities of Great Britain, not excluding the metropolis, you haven't put your story over. Remember it is nearly 10 years since the people of Britain were able to purchase—or even to see—the quality goods which made your industry famous. There is a tendency for folks to think that British pottery is the whiteware so familiar to tea-shops, station buffets, and even the snooty luncheon at an exclusive restaurant.

One Swedish View

I came back and raved about that exhibition to a visitor from Sweden. He was polite—but unimpressed. He had only seen the products of your industry appearing in the shops, and in spite of my explanations of Board of Trade regulations, the export drive, the dollar gap and the continued platitudinous prattle that goes on concerning these, he still thought that products he bought in the shops in Sweden, which were made in Sweden, were better value, better quality and considerably beyond that which was being produced in this country.

Now this is nearing stark tragedy, for after all, the pottery craft in Sweden is in reality undeveloped as compared with even other European nations—let alone Britain. And if you don't believe me, have a glance at the *Encyclopædia Britannica*. Yet the Swedish visitor to Britain fails to see the quality of our goods.

And that goes for the hundreds and thousands of visitors who pass through our ports each year and whose impression of contemporary art, cultural and technical prowess is gauged by what he sees in the shops.

I gather the British Pottery Manufacturers' Federation is trying to do something about this problem of getting good ware to some extent on the home market. What is the use indeed of hiding our quality under a bushel, even from our own folks, and visitors to our shops.

The trouble in this world is that he who shouts loudest tends to get an audience. Believe me, that Hanley exhibition was a reflection of a British craft industry which would have delighted the eye of a connoisseur.

Why Not Television?

We have got a television set-up now tied to the Midlands. In all sorts of programmes, such as Picture Page and the News Reel, viewers are shown all kinds of wonderful things, from a straight corkscrew in Leslie Harden's Inventors' Club to a Martian monstrosity in Joan Gilbert's collection of bric-a-bac. The B.B.C. television service and the news reel had a wonderful story which could have focussed light upon the pottery industry and thrown it on the screens all over Britain, the Dominions and many overseas countries.

I know to you folks in Stoke the idea of publicity is slightly abhorrent. The maker's name "stamped on the bottom" is good enough.

But I would remind you in all sincerity of the number of articles

which were household words some 25 years ago and which are now forgotten except perhaps for a few rusty enamelled signs passing into decay as has the product itself.

You are selling in a world where publicity means a lot. You may think it undignified and may think it unnecessary—you may think it immoral—but the fact is that with the growth of popular education, the cinema, television, magazines, hoardings, scintillating road signs and the like, the inferior product blazoned to the world often rings up more success on the cash register than one which sits on its laurels.

Wider Publicity

You have got to get that message of good British pottery put over both at home and overseas in a much bigger way. Famous names and famous products are one thing—but they are outside the pocket of all but a few wealthy members of society, both at home and overseas. It is that great, large teaming mass of people who like and appreciate beauty but who are conditioned by what they can afford which matter.

In telling the story of the British motor-car industry, it is no good harping on a Rolls-Royce. Everyone agrees it is the world's best motor-car, but it is hardly likely to be a severe competitor to the foreign motor trade. It is the little Austins, Hillmans, Morrises, and so on which are the competitors; the products for the lower and middle income groups—these are the folks that count. They keep one another in business, for it is their purchasing power which makes the wheels of industry revolve.

The millionaire can wear but one suit of clothes at a time, ride in one motor-car at a time, or eat one good meal at a time; it is the many who are the voracious market, and it is to them that the idea of British pottery has got to be sold.

Devaluation is one thing—but, apart from America, it was offset all over the world by the other countries devaluing their currency.

I missed the President of the Board of Trade at this exhibition. Maybe he was asked and could not come—that I don't know. But he manages to turn up to grace the presence of similar occasions in industry far less important than pottery. All I am going to say is that you put on a wonderful show—but to whom did you tell the story, apart from the converted? I know it was a learned Society's Conference. But the showpiece was the product of a great British industry. Maybe in the time for which the exhibition was open a few visitors came along. But was any real publicity given to this show, either before or subsequently? It scarcely reached the national newspapers; I don't think it got even an honourable mention in the B.B.C.'s news bulletin or radio news reel.

The point is that you have got a fine product, a fine background, a fine cultural tradition and a flair for inventive genius in the art and craft of pottery making. But time and time again I hear folks outside the Potteries dismiss Stoke-on-Trent as a dark, dismal city which is part of the "black country."

I know it is not, for I have spent a lot of time there. It is these others you have got to tell—not me.

Donald Mills Exhibition

Now this is what I mean: Donald Mills studied pottery at the Croydon Art School before the war and also when he was in the R.A.F. He is having his third exhibition at the Paul Alexander Galleries, 190 Church Street, Kensington, London, on the 15th May. He has concentrated his development upon copper red stoneware, and believes that he has achieved considerable success. He says he "is now faced with another problem." It would seem that he has accomplished the impossible and created a monochrome glaze effect, the secret of which was lost with the K'ang Hsi potters. He makes no claims about this, but puts his pots on show in the hope that many collectors will come along and turn over the pieces in their hands.

Now that is what I call salesmanship—obviously he feels he has something good, otherwise the experts will soon tell him what they think. But he realises that he has got to get them there. A discovery of a lost Chinese secret in pottery—what could have a greater pulling power!—Even the most blasé and cynical will go along.

(Photo: "Sentinel," Hanley.)

At the civic reception in the Lord Mayor's Parlour. This group includes: Professor Astbury, W. H. Taylor, Mrs. Whitehouse, the Lord Mayor, Dr. A. T. Green, Mrs. Astbury and M. S. Whitehouse, president of the Society

British Ceramic Society Jubilee Meeting

A "CERAMICS" REPORT

THE outstanding event in technology for April and indeed 1950 was the British Ceramic Society Jubilee.

The organisation was as near perfection as attainable by common clay, and more than 400 members who attended the conference confirmed this. In spite of a large number of folks being marooned more or less in the wilds of Buxton as a result of a snowstorm occurring after the introduction of summer time, the flexibility of the organisation did not falter.

The conference opened with a civic reception by the Lord Mayor of Stoke-on-Trent, Ald. Dr. A. P. Spark. An opening address to the conference was given by Prof. W. T. Astbury, M.A., Sc.D., D.S.C., F.R.S., a Longton man who is Professor of Bio Molecular Structure at Leeds University. Visitors were welcomed from Sweden, France, Belgium, India, Italy, Egypt, Holland and Denmark.

Civic Luncheon

The civic lucheon given to the conference by the City of Stoke-on-Trent was enhanced by their kind permission to use the civic plate, which made its appearance, it is believed, for only

the third time since the war. This plate represents the combined efforts of some of the leading pottery manufacturers in the area and as the president of the Society, Mr. M. S. Whitehouse, M.B.E. said, "it was an occasion to be able to wine and dine again from some decent plate and glass."

After a welcome by the Lord Mayor, the president of the Society talked of the objects of the Jubilee. Stoke was chosen as its main venue because appropriately enough the Society was first formed there and it was the early pioneers of the pottery industry who had spent so much of their life in welding together a technical society which now covers ceramics in its broadest aspect. The president outlined this threefold interest by the Society in the form of existing sections dealing with pottery, refractories and building materials.

In discussing the growth of the Society, he paid tribute to Dr. Mellor who was remembered with respect, and to Dr. A. T. Green, O.B.E. who now "carries on his tradition."

Exhibition of Pottery

In the afternoon, members of the conference went to the Victoria Hall, Hanley, to see an exhibition of British pottery. No attempt was made to use the customary paraphernalia of background and display which one associates with exhibitions. There was a simple 6 × 4 table with a white tablecloth for each of the exhibitors. On these were arranged the products of the world-famous and well-known names in British pottery. It is doubtful if anywhere in the world there could be staged such an exhibition of production pottery as a contemporary craft.

It seemed a pity that this nation of ours, which has been starved so long of the decorated products of its industry, should not have been there to marvel in the exhibition itself. Nevertheless, with that display living in the minds of the citizens of the Potteries, there is no need for them to worry that any nation in the world is likely to usurp their position easily. That exhibition, so simply staged, crystallises the heart of one of Britain's greatest industries, and the quality of the exhibits could be best summed up by saying that no visitor was able to make a frank and honest expression as to which display was best. Whilst one held immediate interest and led to a selected preference, this conclusion was hastily dashed by gazing upon the next.

To all those manufacturing who supported the exhibition, one must give full marks for a most impressive display, in which the goods themselves took pride of place, and where the modern tendency of introduction by patter and trumpets was unnecessary and omitted.

President's Dinner and Dance

In the evening more than 250 members and guests attended the dinner and dance of the president of the Society at the Palace Hotel, Buxton. The toast to the President was proposed by Mr. F. West, M.I.Mech.E., M.Inst.Gas.E., a past president of the Society, and in responding the president said that his "grandfather's grandfather was a Staffordshire brickmaker, and if his ancestors had been there that night they would probably have said, 'What are you meddling with these Societies for?' They would probably have added 'Look at the expense'." In conclusion the president expressed thanks for the excellence of the arrangements to Dr. A. T. Green and members of his staff, including Mr. F. H. Clews and Miss Ellis.

After the reception, the conference settled down to work in earnest. Visits were arranged to factories covering refractory, pottery and building materials sections. In the afternoon the three sections held meetings at which the following papers were presented and discussed:—

"The Development of Firing in the Pottery Industry" by A. Dinsdale.

"Fifty Years of Progress in Ceramic Whitewares" by W. L. German and W. S. Ratcliffe.

"Developments in the Manufacture of Silica Bricks" by T. R. Lynam.

"Fireclay and Alumino - silicate Refractories in the 20th Century" by F. H. Clews.

"The Heavy Clay Industries, 1900-1950" by W. Noble.

"Firing in the Heavy Clay Industries, 1900-1950" by E. Rowden.

The Jubilee dinner of the Society

BRITISH CERAMIC SOCIETY'S JUBILEE DINNER

(Photo: "Sentinel," Hanley.)

The gathering at King's Hall, Stoke-on-Trent, 26th April, 1950

took place on Thursday evening in the Kings Hall, Stoke. In proposing the toast to the Society, Professor J. W. Cook, F.R.S., president of the Royal Institute of Chemistry said that ceramics provided a meeting place for science, technology and the arts. Since chemistry was the underlying science in the industry he recalled the great work done by Dr. J. W. Mellor, and drew attention to his successor Dr. A. T. Green who was now entering another term of office as a member of the Council of the Royal Institute of Chemistry thus providing a continued link between chemistry and ceramics. The president in responding stated the aims of the Society and said, "We stand for the dissemination of knowledge for knowledge's sake. In toasting the Ceramic Industries Mr. S. Robson president of the Society of Chemical Industry said that Staffordshires fine china was the pride of England . . . In responding Mr. H. J. Plant president of the British Pottery Manufacturers' Federation drew attention to dollar exports but deplored the absence of decorated ware from the home market which depended upon the great craftsmen—male and female—in the British industry.

Congratulations were received as well as gifts from Denmark, Holland, the American Ceramic Society and the Swedish Brick Manufacturers' Association.

Vitally Important Papers

Thursday was again spent in visits and then there was a general meeting of the Society in the North Staffordshire Technical College, which discussed three vitally important papers for the industry, namely:

"Technical Education for the Clayworker" by the president.

"Education in the Ceramic Industries" by W. L. German.

"The Universities and Ceramic Education" by Prof. A. L. Roberts.

The president mentioned means whereby educational requirements for the heavy clay industry could be met on lines similar to those included in the pottery section of the North Staffordshire Technical College. Dr. German drew attention to the transition today towards the application of modern engineering principles in ceramic manufacture and outlined how this was being covered at the North Staffordshire Technical College.

Ceramics Degree

Professor Roberts suggested that the increasing demand for technologists could be met by an expansion of the universities and mentioned that consideration was being given by the University of Leeds to the granting of the degree of B.Sc. in ceramics.

In concluding this report of the jubilee ceremonies of the Ceramic Society one is compelled to the conclusion that seldom has any professional society in the fields of technology achieved such a masterly display of its activities and it was indeed pleasant to see all aspects of the industry from manufacture and commerce to research and development profiting by listening to the other fellows point of view. This indeed is the prime reason for the existence of any such Society but it is not always realised so fully as on this occasion.

In the course of the conference the following works were visited:

Thomas Marshall and Co. Ltd., Sheffield.
General Refractories Ltd., Worksop.
Oughtibridge Silica Firebrick Co. Ltd., Oughtibridge, nr. Sheffield.
Ensor and Co. Ltd., Woodville, Burton-on-Trent.
Berry Hill Brickworks Ltd., Stoke-on-Trent.
G. H. Downing and Co. Ltd., Chesterton, Staffs.
John Slater (Stoke) Ltd., Stoke-on-Trent.
British Thompson Houston Co. Ltd., Chesterfield.

The following manufacturers of table ware and wall tiles in the Potteries district have kindly offered to show a small group of visitors round their works

T. C. Wild and Sons Ltd.
Doulton and Co. Ltd.
W. T. Copeland and Sons Ltd.
Minton Ltd.
Josiah Wedgwood and Sons Ltd.
Shelleys Potteries Ltd.
H. and R. Johnson Ltd.
Richards Tiles Ltd.

British Ceramic Society Jubilee Conference

A SUMMARY OF THE TECHNICAL PAPERS

The following abstracts of papers given at the Jubilee Conference of the British Ceramic Society are reproduced here by kind permission of the Society.

THE DEVELOPMENT OF FIRING IN THE POTTERY INDUSTRY

by A. DINSDALE, M.Sc., F.Inst.P.
British Ceramic Research Association

ANY study of the development of firing methods in the pottery industry may properly begin by noting that this is a subject which has always been of keen interest to those who are associated in any way with ceramics, and a glance through the reports of the meetings of this Society shows that whenever the topic is brought up it gives rise to vigorous and fruitful discussion. As in many other walks of life, the story of this half century is one of change in method and technique to an extent vastly exceeding anything that went before. The old bottle oven, so long a symbolic feature of the skyline in the Potteries, having itself undergone changes in an attempt to keep pace with the progress of ideas, is now fighting a losing battle. It is being replaced, at an ever increasing rate by the tunnel oven, which represents by far the most important change of practice during the period. The change has brought with it new problems, and new opportunities for manufacturer, technologist, operative, kiln builder and research worker. The present paper seeks to trace the history of the changes which have occurred over the last 50 years, and to relate cause and effect in the progressive development of firing methods.

Intermittent Ovens

The intermittent bottle oven represents the traditional method of firing pottery ware, and much has been said and written about it. Firing by this method requires considerable skill and understanding, and is not altogether as crude a process as is sometimes imagined. Nevertheless, it has serious disadvantages and it was a realisation of these which led to changes in design and operation within the same structural principle.

Early attempts to determine the thermal efficiency of the intermittent oven showed that the amount of heat used in the treatment of the ware was very small in proportion to the heat lost by radiation from the walls of the oven and in the hot products of combustion leaving the top. An analysis of this heat balance led naturally to the conclusion that the best way of improving the efficiency was by cutting down the losses from these two latter sources. It was thus that the downdraught system came into use, since by this means the combustion gases travel a longer distance through the goods, and therefore give up more of their heat before leaving the oven. In some applications of this principle the gases are taken out by way of flues in the wall brickwork,

and thus further reduce the losses due to radiation from the structure. Tests on the two types show that the fuel consumption per unit weight of setting is generally about 25 per cent. less for the downdraught than for the updraught. The radiation losses are sometimes further reduced by the use of high temperature insulation of the crown, walls and floor of the oven.

Mechanical Stokers

Apart from the poor heat utilisation the intermittent oven, as normally fired, has the disadvantage that the setting is subject to variable conditions of atmosphere and temperature rise according to the state of the fires. In order to minimise these effects and to establish more uniform conditions much attention has been given in recent years to firing technique. The use of special firemouths has been explored, as also has the use of fuel oil or gas instead of coal. But the most interesting approach to the problem has been the attempt to feed the coal to the fire in a progressive and uniform manner by mechanical means. Several different designs of mechanical stoker have been tried but they do not seem to have been widely adopted. This may be due to the high capital cost, but more probably to the fact that no system has yet been devised which will deposit the fuel in the correct place on the firebed.

At the time of writing, in spite of these improvements, it does not seem likely that the traditional type of coal-fired oven will survive in the future, although there are circumstances in which an oven of modern design, operated on the intermittent principle and heated by gas or electricity, may be a feasible proposition.

Tunnel Ovens

It does not appear to be known with precision when the tunnel oven system was first discovered, though it is generally agreed that it was early in the 18th Century. A kiln of the continuous type, through which the ware was pushed, was in operation at Vincennes in 1751. There appear to have been very few improvements in design until about the middle of the 19th Century, when the idea of using trucks with iron wheels emerged, probably for the firing of bricks. At the beginning of the 20th Century several different types were built in France, the only successful one apparently being the Faugeron. Open-flame kilns were designed in this country by Williamson and Marlow, mainly for tiles. Meanwhile, the use of muffles was being developed, and Dressler installed his first muffle tunnel kiln here for glost tiles in 1912, and this seems to have been the first tunnel to be built in Stoke-on-Trent. The period following 1920 seems to mark the beginning of considerable interest in tunnel firing in this country. In 1928, in a paper read before the Society, it was predicted that "one may confidently assume that tunnel kilns will be responsible for more than half the country's output of pottery within the next few decades."

In the decade between 1930 and 1940, the industry may be said to have become tunnel kiln conscious, and following the hiatus caused by the war period, many new ideas are coming to light in the rapid development which is now taking place. Many experiments were carried out in the early years of the century on the use of electricity, but the first high temperature kiln using this source of heat in this country was installed at Barlaston in 1939. This was a twin-tunnel kiln firing biscuit in one direction and glost in the other. The latest development in this direction has been the recent installation of an electrically heated kiln for china biscuit, the elements in the firing zone being of silicon carbide on account of the high temperatures required for this type of ware.

One of the most profound changes in outlook which accompanies the introduction of the tunnel oven is a shortening of firing schedules. More and more rapid firing is becoming the accepted practice, and consideration is now being given to the practical application of the very short time in which it is known that single articles of ware can be fired. Thus a feature of present day practice is the number of trials which are being made with moving belt and passage type kilns.

Uniform Heat Treatment

Many attempts have been made to improve the uniformity of the heat treatment which the ware receives,

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5. Paper drying.
6. Flax and Linen drying, etc.

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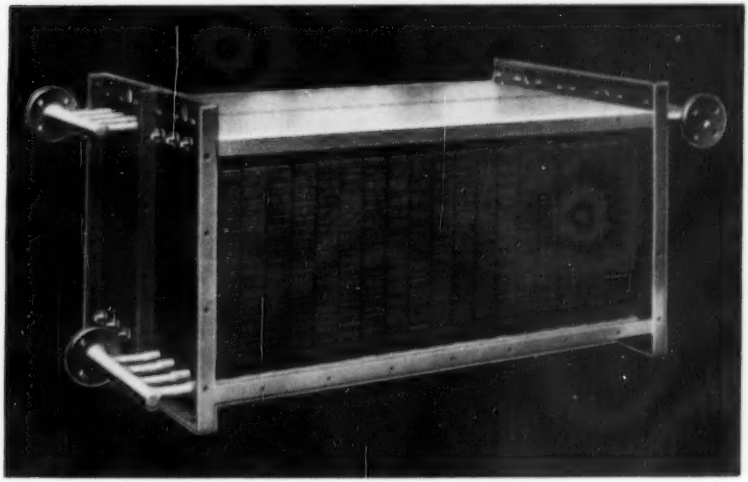
3. Required outlet temperature.
4. Humidity Conditions.
5. Cooling medium and its flow and return temperature.



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and particularly to reduce the temperature differences which are known to exist between different parts of the load in the preheating zone. Positive fan circulation has been tried, and seems to have been successful in some cases but not in others. An interesting development in recent years has been the use of high velocity air jets to set in motion the whole of the kiln atmosphere around the setting, and in electrical kilns heaters have been placed on the car decks to increase the bottom heat. In muffle kilns, the tendency for the tops to be overheated has been mitigated to some extent by sloping the wall of the muffle, by constructing the lower sections of the muffle wall of highly conducting material, and by arranging for the centre of combustion to be towards the bottom of the combustion space. An ingenious method of obtaining still better vertical control is to be found in the radiant tube type of muffle kiln, in which the heating gases pass along the wall in a series of radiating tubes, each subject to separate control.

Relative Merits of Intermittent and Tunnel Ovens

Although the tunnel oven is rapidly replacing the intermittent, there is still a certain amount of resistance to the change and a body of opinion not yet convinced of the attendant advantages. It is, therefore, of interest to look at some points of comparison, and to note that from a national standpoint the tunnel has the advantage that it improves the utilisation of fuel and abolishes smoke. The question of thermal efficiency, however, is not of itself decisive, since the type of fuel used may be more expensive than coal. Improved quality, lower maintenance costs, and labour costs reduced by 25 to 50 per cent., are other advantages which have been claimed. The saving in losses due to dirty ware and other defects in glost firing may well have been an appreciable factor responsible for the fact that tunnels first became established for glost firing rather than for biscuit. Although there is still not enough information available concerning the financial aspect, such as there is indicates clearly that considerable savings can be made by using the tunnel oven system. Typical figures show that for earthenware biscuit the fuel cost may be from 20 to 35 per cent. less; for sanitary fireclay the cost of fuel and labour is reduced by about 50 per cent.; while for tiles, a detailed analysis including fuel, labour, repairs and depreciation shows an economy of about 35 per cent. of the intermittent figure. Although the capital cost of tunnel ovens is admittedly heavy, the figures quoted above indicate that it can be recovered in a reasonably short space of time.

The Measurement of Efficiency

The past 20 years has seen great advances in methods of determining the efficiency of working of kilns. The use of travelling thermocouples, for instance, passing through the kiln embedded in the ware gives an accurate and detailed record of the actual firing schedule. Standard methods of test have been worked out by means of which the thermal efficiency and heat balance for a kiln can be computed, in such a way as to make comparison easier between one kiln and another. These tests have now been carried out on a large number of kilns of all types, firing different types of ware, so that a body of evidence has been accumulated which will serve as a basis for improvement in design and in operation.

Further progress along these lines will need a consideration of the meaning of the term efficiency, and its relation to certain features peculiar to the operation of a particular kiln. It will be necessary to settle whether larger kilns are inherently more efficient than smaller ones. The question of throughput will need to be allowed for, since it is well known that higher throughput can be obtained by increasing the speed without a proportionate increase in the fuel consumption, thus giving rise to an apparent increase in the efficiency. Further, a kiln operating at a high temperature and subjecting the ware to a good soak, will require more fuel and appear to have a lower thermal efficiency on the conventional basis. The definition of an overall merit figure taking these factors into account will make for a more adequate comparison between kilns of different design.

All the well-known types of fuel have been used for firing pottery, although in recent years the emphasis has been shifting from primary to derived fuels. The most popular fuel at the present time seems to be town gas, but electricity as a source of heat for high temperature firing is coming more into the picture with the development of suitable elements. In assessing the relative costs of fuels, a distinction should be made between the net and the gross cost, the latter including charges dependent on the amount of auxiliary plant and labour used in burning the fuel. When the gross cost of the fuel is co-ordinated with the efficiency of utilisation in the kiln an estimate can be made of the total fuel cost involved in the firing process.

Gas or Electricity

With gas and electricity, the high cost per therm of the latter has to be set against the advantages of open placing and low flue gas losses. For biscuit firing with electricity, only about half the amount of heat is required to fire a given setting volume; taking the cost per therm as about three times that of gas, and allowing about twice as much ware with open setting as with saggars, it seems that the resulting overall costs are not much different. For glost firing, the figures which are available show great variations from kiln to kiln but indicate that gas is the cheaper form of heating. It does not follow, however, that this advantage will be maintained in the future, since gas has enjoyed an advantageous position with regard to price increases in recent years. A consideration of the relative increases since 1939 shows that there is a possibility that the favourable position of gas will decline. Much more information is needed on firing costs before any sure conclusions can be drawn, and the only thing that seems certain is that the diversity of pottery firing is such that both sources of heat having much to commend them in their different ways will continue to play a prominent part, side by side, in future developments.

Of the fuels not directly linked with coal, heavy fuel oil seems most likely to be used, and its high calorific value may prove to be its strongest asset. In many fields of modern ceramics the movement is towards bodies and manufacturing techniques which will need higher firing temperatures. This presents few problems in America, with natural gas of high calorific value available, but in this country it may become necessary to use oil more extensively than is the case at present.

Future Trends

The mind of an industry, no matter how firmly based on traditional ideas is never static. Great as have been the changes in pottery firing during the past 50 years, nothing is more certain than that more change awaits us around the corner. The tunnel oven has come to stay, but has not yet reached the end of its development. There are several fields in which progress will be made as more data become available for consideration. There is need for a better understanding of the properties of bodies, particularly in respect of their behaviour on heating. Better methods of assessing the performance of kilns are required, taking account of factors inherent both in the design and the operation of the unit. The trend towards faster firing means that the margin of error allowable in fulfilling the basic requirements of the ware is becoming less, and this implies the necessity for a study of the relationship between firing schedule and quality, for articles of varying size, thickness and shape. Much of the improvement in the control of the heat distribution in tunnel kilns has taken the form of a reduction in variations across the setting, but a pressing need is concerned with the control of longitudinal variations. It is not yet possible to alter the shape of the firing curve in particular sections as easily as is desirable for the best possible working. Lastly, an important field for further study is the effect of continuous firing on properties. It is obvious that certain factors such as the relationship of glaze to body, the nature of the pore system within the body, the maturing properties of the glaze, and so on, may be affected by the change from intermittent firing, and a careful study of these would be worth while.

In these, and in many other ways,

much remains to be done, and the progress we have noted in the past, great though it has been, can be but a stepping stone to the future.

FIFTY YEARS OF PROGRESS IN CERAMIC WHITEWARES

by DR. W. L. GERMAN and W. S. RATCLIFFE

WE have the task of trying to inform you of the development which has occurred in the whiteware industry over a period of 50 years in about an hour. With such a short time available you will quite realise that it is impossible to treat the subject comprehensively. We have tried to divide this paper into different sections and to discuss briefly the development in each section. Some of the sections are very short, but we would like it understood that this does not necessarily mean that little advancement has been made in this particular field. The time available does not allow for any further treatment.

Raw Materials

Little change has taken place in the preparation of ball clays. In the last few years dried air floated clays have begun to be produced, but as yet there is no sign that the majority of potters regard the increase in cost as being worth while. This contrasts with the American practice where dry ground clays are essential for the dry mix process.

Considerable research has been done on the properties of china clay, and centrifuging is now being adapted to control the grain size of various grades. De-watering is done extensively with filter presses in place of the heated floor kiln. A working party report suggests that a specification be introduced for the control of the quality of china clay, and this would probably present little difficulty if the trade could agree on its requirements.

Naturally of interest to the English potter is flint, and there is much in the literature concerning this material. During the last 10 years or so the investigations have shown that a change in specific gravity occurs on calcination at temperatures as low as 300° C. with only a slight change in value up to 900° C. The alteration in specific gravity at the low temperatures is due to liberation of water and not to any change in the flint to cristobalite as at one time thought.

The grinding of both flint and stone in pans is now tending to change over to cylinder grinding. The latest development is "closed circuit" grinding, where the material is removed continuously from the cylinder and its grain size checked with a classifier.

Body Preparation

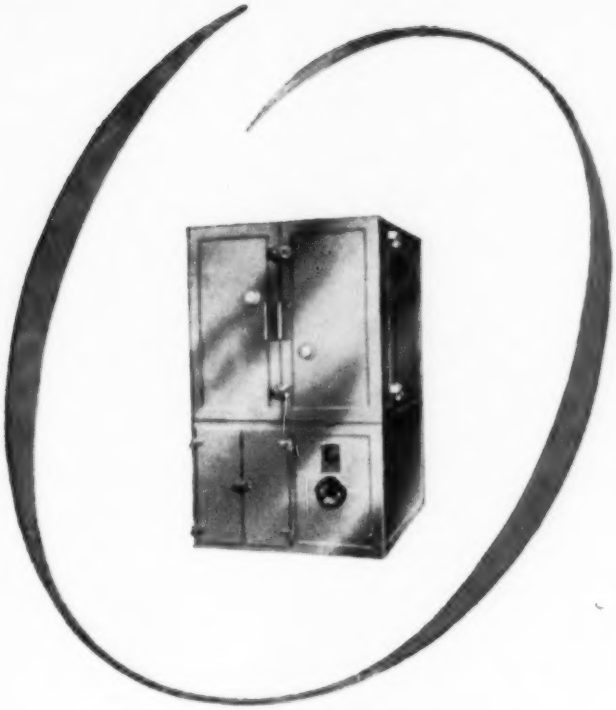
As far as body preparation for whiteware is concerned, there have been no striking changes. Both the dry method of mixing and wet method of mixing are still carried out, with the dip stick as the measuring device. There are some factories which control their mixing by weighing the slip instead of using the pint measure and dip stick.

Steel presses are taking the place of wooden ones, and nylon press cloths have been introduced. The use of the de-airing pug has increased rapidly, and considerable improvements have been made in the design of lawns and magnets. Additions of small amounts of ball clay, bentonite and Florida kaolin to the bone china body to allow working with machines has now become rather widespread.

In the U.S.A. the emphasis is now on dry mixing methods for pottery bodies. This involves grinding the clays and other materials and mixing them in the dry state. The requisite amount of water is then added and the process completed by further mixing, and if a plastic body is required, by pugging.

Air floated materials are being used in this country to a limited extent, but whether the whole industry or the factory inspectors would view very favourably the handling of dry powdered flint is doubtful.

An interesting development in this district for the continuous preparation of tile dust is the use of a heated drum for de-watering. For this purpose the



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Making Methods

One of the revolutionary changes which has taken place in the last decade is the extent to which the shaping of claywares has been mechanised. The present shortage of labour has accentuated the trend. Production with fully automatic machines has been a notable development in the U.S.A. and the production rates with such machines are high. A single line Miller machine will produce 8 in. plates at 100 actual dozens per hour. An eight line machine operated by four men gives an output at the rate of 640 dozens an hour. Clay losses are heavier than on machines operated at slower speeds. These figures do not take into consideration any stoppage which may result in about 20 per cent. lower output than the above figures suggest.

In this country mechanisation has proceeded in the direction of semi-automatic machines, although at Barlaston there is a Wedgewood Sultzer fully automatic machine in operation and another fully automatic machine is under construction elsewhere. While the semi-automatic machines do not give the high rates of production of the Miller machine, they nevertheless give outputs of 2,000-2,500 per day. With these machines the operator has to make and throw on the bat of clay. A recently patented machine for flatware uses a new principle of rolling the clay on the mould instead of making it with the usual profile. In the cup machine developed in this country all the operator has to do is to throw the clay into the mould. Each machine operated by one worker gives an output of about 3,300 per day. As many potters have found, higher production rates demand increased rates of drying. The old heated stillage is now regarded as obsolete and has been replaced by "dobbins" and mangles. Other mechanical aids to production are machines for cutting handles and for the operation of putting the handles on cups.

A machine has recently been evolved for the turning of cups to shape. The cup is held on a vacuum chuck and the tool moves over the cup to a predetermined outline. Bone china cups can be turned at the rate of 160 dozens per day with one unskilled operator.

Casting operations are now being mechanised by what is known as "station casting." In this method the moulds run round on a conveyor belt. At one point the slip is poured in. It then passes to the next where the mould is emptied. From here it goes through a drying tunnel to give mould release, and on emerging the cast article can be removed and the mould passed on.

Decoration

Printing is extensively used for under-glaze decoration and it is customary, where large quantities are required, to use the roller type of printing. The "rubbing on" of transfers is in many instances being done by machines, either a mechanical "rubber" which will rub down five prints per minute, or the pressure cabinet. The manufacture of lithographs has seen some important changes. Zinc and aluminium plates are now replacing litho stones with considerable advantage in production costs and storage facilities. Photographic means of producing the colour plates required for printing the transfer sheets are now being used, with reduction in labour entailed and improved quality in the finished product. Lately the silk screen process has been adapted to producing transfers on sheets of colodion. It can be adapted to designs in several colours, though it cannot give the same effects as those from the usual litho. The thick deposits of colour are, however, an advantage in some types of decoration.

Gold lining and banding can now be mechanised. A machine was originally produced in Canada and one is now being made in this country. It is claimed that it doubles the output with considerable economy in gold consumption.

Glazes

At the end of the 19th Century lead compounds in the raw state were being used almost entirely as constituents of glazes, with the result that lead poisoning had reached alarming proportions. The disease was so bad that the industry was officially declared to be dangerous. The number of cases of lead poisoning reported in 1898 was 457. In 1913 the Pottery Regulations came into force and also the use of low solubility glazes, which has resulted in a marked decrease in lead poisoning, so much so that in 1949 no cases of lead poisoning have been reported.

Much work has been reported on the effect of certain materials on the solubility of lead frits. Alumina and titania have a marked effect on reducing the solubility, whereas lead frits high in alkalis and boric acid show a high solubility. Another important contribution to the solubility of frits was made in 1948 by H. L. Podmore. He coated the frits with an insoluble material and by such means enabled a frit of high lead content to pass the Government solubility test.

Glaze Control

Our knowledge of the physical properties of glazes has increased during the period under review. The importance of viscosity and thixotropy in glaze control began to be appreciated. Glaze control at the present time is probably more or less the control of differential sedimentation of heavy or large particles and also the attainment of the correct thickness of glaze by control of viscosity and thixotropy.

Development in the application of the glaze has been chiefly in the tile industry, where the flat surface lends itself to mechanisation. The two types of automatic glazing machines which have come to be used are the roller type dipper and the cascade dipper. Automatic dipping for tea and dinner ware has not progressed much in this country, although a machine for glazing of saucers is in use at a local works. An output from such a machine is about 300 dozen an hour.

The problem of the crazing of glazes is one which has concerned many investigators during the last 50 years. Up to about 1938 there was much confusion existing on the question of crazing and peeling, until it was realised that glazes need to be under a compressive strain to resist crazing. Glazes are weak in tension and very small tensile stress values result in crazing. The compression strength of a glaze, however, is very high, and a glaze can sustain high compressive stress without showing any ill effects. In 1929 Schurect and Pole published their results on the effect of moisture on the body, and reported that bodies in general expand when exposed to moisture. This moisture expansion is in general higher with porous bodies than vitreous bodies. Probably, at the present time, crazing is more a problem of delayed crazing.

Examination of ceramic ware in use or in storage shows that the stress in the glaze developed during the cooling in the glost oven does not remain constant during ageing, but the glaze compression decreases and tension often arises causing delayed crazing of the glaze. This is explained by the moisture expansion of the body decreasing the compression of the glaze. Many other factors on crazing such as glaze penetration during maturing, the annealing temperature, and the effect of the oxides in the glaze on its thermal expansion have all been studied. Many investigators have reported on the effect of the glaze on the finished strength of the ware. The mechanical strength, measured by the modulus of rupture or transverse strength, increases with decrease in thermal expansion of a glaze. A glaze in compression and of good crazing resistance increases the mechanical strength of the ware.

One aspect in glaze development which up to a few years ago had received very little attention was the quicker firing of glazes. With the advent of certain types of tunnel kilns for glazed ware, where the firing of glost is in 3 to 4 hours, quick maturing glazes were developed. Such a glaze is usually high in frit, and one stage of future development will certainly be the production of such a glaze.

Bodies

Certain types of bodies have ceased more or less to be manufactured, for

example the parian and granite type of bodies. The Jasper, Basalt are still being made, as also the Samian, Rockingham and Jet types. The composition of earthenware and bone china bodies has changed very little over the period. The development has been more in the understanding of the properties of the raw materials and greater control during manufacture.

White wall tile bodies are still of the composition ball clay, china clay, flint and stone, but for tile surrounds there has been a definite tendency to use fire clay or ball clay with and without flint as the body materials.

In America the trend has been to use pyrophyllite and talc, but these materials have not made much headway in this country because of expense.

FIRING IN THE HEAVY CLAY AND REFRACTORIES INDUSTRIES, 1900—1950

by E. ROWDEN, B.Sc., D.I.C., F.R.I.C.

FROM the patents it is seen that the main principles involved in the design of intermittent kilns, and of Hoffmann, Belgian, chamber and even car tunnel kilns were established before 1900. Progress since that time has largely been in the erection, development and improvement of these types of kilns and in using them to fire various types of goods satisfactorily.

Historical Survey

Early kilns were intermittent updraughts, such as the Scove or Scotch kiln, the Dutch kiln and the Suffolk kiln, which were all in use before 1875. Downdraught kilns, both round and rectangular of good design were certainly in operation before 1870. The rectangular kilns had either stacks on the side walls or external stacks; round kilns had either an internal stack at the centre, or a centre well hole connected to an external stack. Many patents were taken out between 1870 and 1890 on parallel flues, radial flues, ring flues, combined ring and radial flues, etc. in the floor to the round kiln to give better temperature distribution.

The original barrel arch continuous kiln, top-fired, was patented by Hoffmann and Licht in 1858. This 12 chamber circular kiln with stack at the centre was improved in 1870 by Hoffmann to the oval shaped kiln still utilised to the present day. The archless continuous kiln, built in the ground, was patented by O. Bock in 1899. In 1877, H. Guthrie patented his firing trough which was incorporated in the Guthrie continuous kiln. This lead to the use of transverse grates across the chambers of barrel arch kilns, and consequently to the Belgian kiln patented by Dubois Enghiens in 1891, 1894 and 1895. J. Buhrer patented his zig-zag kiln in 1867, which was modified in 1912. Hot air flues were provided on the original Hoffmann and Buhrer kilns; modified designs were put forward by Dean, Dean and Hetherington, Osman, Brown, etc. from 1893 to 1898. The use of fans for kiln draught and for hot air extraction was advocated in 1858.

Top fired transverse arch chamber kilns were also introduced before 1900, notably Vaughan's kiln in 1895. The original gas-fired continuous kilns known as "candle" kilns were normal barrel arch kilns with producer gas supplied to a series of pipes or candles, one within each charge shaft. Pioneers were Mandheim Escherisch, Hotop, etc. Patents for gas-fired transverse arch kilns were taken out by G. Mendheim (1873), Youngren, Mason and Wilson (1898), and J. Dunnachie (1881). Dunnachie kilns were built at Glenboig and are still being used. Mendheim modified his design a few years later to types now being used.

Tunnel Kilns

The first tunnel kiln was built as early as 1751 to fire colours on porcelain. Further kilns were patented by Yordt in 1840 and E. Peters in

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1858. The same general principles as on these two kilns are still used; they failed because it was not possible to prevent the heat from destroying the cars. O. Bock (1877) placed fire clay slabs on the cars, fixed iron plates to their sides, which dipped into troughs filled with sand, and provided a space beneath the cars through which a current of air was passed. A number of these kilns were built but were not entirely affective because they were too short. Problems of effective sealing of the cars and of their propulsion were largely solved by 1900. Muffle type kilns were patented by Helzel (1875), Turton (1899), and others, but the most successful was that patented by C. Dressler in 1910. As regards direct fired tunnel kilns early patents were taken out in 1881 and onwards, the most important being that of Faugeron (1898) which was further improved in 1913. This kiln had drop arches in the crown and spaces in the side walls to cause the gases to flow up and down through the setting.

Intermittent Kilns

These still predominate in the firing of many products. The updraught kilns have been largely replaced although they are still used in a few districts for firing pantiles, Roman tiles and silica bricks. Single Newcastle kilns have largely given way to the double kilns with firemouths at each end. Downdraught kilns have been improved in design and are now built to design. Fireholes with stepped gates, inclined bars or horizontal bars have replaced those with solid floor; top and bottom firedoors and slide controlled primary and secondary air flues may be adopted for better control of combustion. Larger kilns have been built which are more efficient and floor flues have been adopted which give even temperature distribution. Insulation has been applied both on the hot face and as backing insulation.

The mechanical firing of intermittent kilns have been developed but whether to a fully effective extent has yet to be proved. Overfeed stokers have been applied to the top firing openings, underfeed stokers with air blast to the ash pits and more recently one large mechanical stoker at the centre bottom of the kiln. Kilns of the latter type have been erected for firing salt glazed pipes, silica bricks and floor quarries.

Continuous Kilns

Hoffmann and Belgian kilns differ but little from those erected before 1900, but more of them have been brought into use. The Buhrer kiln was redesigned in 1912; when operated with a fan draught of 4 to 5 in. wg. rates of fire travel of 100 ft./day may be attained.

Top fired transverse arch chamber kilns have been used for firing Fletton bricks since 1890. Some of the early kilns had 16 chambers capacity 20,000 bricks, central stack, main flue in the centre main wall, connections through the inter-chamber walls and 5 rows of feedholes in the crown. Later kilns had 28-32 chambers with capacities of 40,000 bricks and were worked with 2 firing circuits. In 1935 a continuous kiln was built with 80 chambers and holding 74,000 bricks. This kiln had three stacks and was operated with 5 firing circuits. Its chief feature was that bricks were fired on cars which were pushed into the chambers from the brick presses and after firing were pulled out to the loading bay or stock yard. In 1935-37 semi-continuous kilns of 80 chambers were built; these had 5 stacks, chambers holding 33,000 bricks and were operated with 5 firing circuits. These kilns had the advantage that the chambers could be set from movable brick presses on one side of the kilns and drawn, and the bricks delivered to the stock ground or lorry on the other side. In some smaller works, Staffordshire and Super-Staffordshire kilns are used.

More Control

The forerunners of the present day producer gas-fired chamber kilns are those of Mendheim and Dunnachie, both of which are still used. Others of this type are the Shaw kiln and the Woodall-Duckham kiln which however is grate fired. These kilns and others have been developed to fire firebricks, silica bricks, basic bricks, to temperatures of 1,200° to 1,450° C. They have the advantage over the barrel arch kiln that with separate chambers there is more control of the time of soaking and the firing.

The greatest advance in the past 50

years has been made with car tunnel kilns. Satisfactory construction and operation was not obtained before 1910 when Dressler put forward his muffle kiln and in 1913 when Faugeron patented his direct fired kiln. Since then progress has been due largely to better construction and greater engineering facilities. Sand seals, tongue and groove fittings of car deck and side walls, undercar cooling, roller bearings to wheels and mechanical car pushing have all been brought into effective operation.

The circular combustion chambers of the Dressler muffle kiln were later modified to those of hollow triangular shape, but more recently they have been further modified in the Thrift kiln by using straight hollow slabs which rest at an angle against the kiln wall to form a triangular combustion chamber.

The biggest improvements during recent years have been on those kilns firing fine ceramic ware, where muffle and direct fired kilns are used fired by electricity, town gas, fuel oil, producer gas and natural gas (in America); straight car tunnel kilns, annular kilns with moving platforms, walking-beam kilns and travelling belt kilns with belts made of nichrome and operating on very short firing schedules, have all been brought into service.

Direct Fired Kilns

Kilns for heavy clay ware and refractories are direct fired. They are mainly side fired and often have an adjacent tunnel dryer heated with hot air from the cooling zone of the kiln. The Monier kiln is top fired with coal mechanically and good uniformity of heating is thereby obtained across the setting. About a dozen car tunnel kilns are in use in this country firing building bricks. Most of these are Brisesco-Harrop kilns or Monier kilns with outputs of 100,000-150,000 bricks per week. In addition there are four car tunnel kilns of German design, fired by hand from the kiln top, used for firing stock bricks. About twenty car tunnel kilns are in operation in this country for firing refractories. Three, coal-fired by hand to grates on each side of the kiln, have been used for the past 25-30 years for firing thin fire clay goods. Six or seven Dressler kilns are in use for firing casting pit refractories to 1,100°-1,150° C.; five to six Harrop kilns are being used to fire high-grade Scotch firebricks to temperatures up to Cone 17. A tunnel kiln fired with raw hot producer gas from bituminous coal has been in operation for 25 years or more for firing firebricks to 1,350° C.; kilns just erected have included one for firing silica bricks and one for firing firebricks heated by cold clean producer gas.

The mechanical firing of top-fired continuous kilns has been largely applied in Germany: it has not been adopted to the same extent in this country but where employed is considered to give more uniform firing, a greater rate of fire travel and a saving of fuel. The mechanical firing of grate fired kilns by sprinkler stoker or underfeed stoker to grate fired kiln has been introduced but has not developed yet. Mechanical top firing of car tunnel kilns has already been indicated for the Monier kiln.

Insulation

Insulation has not been developed to any great extent on chamber or barrel arch continuous kilns, but it has on car tunnel kilns where it can be applied with greater facility and where it is highly desirable because of the large surface area.

Pyrometric control has come to the fore with the advent of the car tunnel kiln. All such kilns are fitted with pyrometers on erection. Their use on intermittent kilns both in the crown and base is gradually extending and permits of better control by the fireman.

Problems of reduction of smoke emissions from intermittent kilns have arisen in many districts. Certain improvements have been effected by better control of the combustion and the use of secondary and tertiary air flues more particularly in the firing of blue bricks, tiles, etc.

Trends in Firing Different Products

Progress in the firing of different types of goods has been very varied. For some, intermittent kilns are still mainly used, for others continuous kilns predominate. To economise in fuel, development should be towards the greater use of continuous kilns, and the trend definitely is in this

direction. Where intermittents are still mainly used, progress has been made however both in firing practice and in quality of product. In America the change over in design has been practically straight over from intermittent kilns to car tunnel kilns, for adaptability the trend now is to use two or more car tunnel kilns of smaller size in preference to one large kiln.

Building Bricks

Ninety per cent. of the output of building bricks in this country are fired in continuous kilns; these are mainly top fired chamber and Hoffmann kilns and Belgian grate fired kilns. There are also a few Zig-Zag or Habla kilns and about a dozen car tunnel kilns.

Stock bricks were fired in clamps until about 1930, when several car tunnel kilns were brought into use. During the past 2 or 3 years it has been found that a much higher yield of stocks, over 90 per cent., and lower waste is obtained with intermittent kilns, and that excellent results are also possible with top fired chamber continuous kilns.

Blue bricks, quarries, and tiles have for the main part been fired in intermittent down-draught kilns because of the reducing atmosphere required in firing and the careful cooling needed. They are still largely fired in this way but some progress has been made with semi-continuous and continuous kiln firing, using chambers of small size coal fed to grates. The goods however, tend to be slightly brindled. In Germany blueing is carried out in Hoffmann and Zig-Zag kilns by closing the stack damper for 2-3 hours when chambers are on top heat and also in car tunnel kilns by making additions to the clay or by applying a reducing atmosphere.

Roofing Tiles

These for the most part are fired in intermittent kilns in this country. Continuous kilns only are used in Germany; these are mainly top fired Zig-Zag kilns, and the tiles are flat or interlocking. Here greater difficulty is met with cambered tiles but the use of continuous kilns is gradually increasing. Some 10-12 continuous kilns are in use including (1) a barrel arch continuous kiln with two grates across the floor of each chamber (40 per cent. bricks set with the tiles, (2) a super-Staffordshire kiln, (3) a Simplex kiln (grate fired chamber kiln) and (4) a producer gas-fired chamber kiln. In each case the tiles are set dry on edge so that the kiln gases flow downdraught through them.

Salt-glazed Pipes

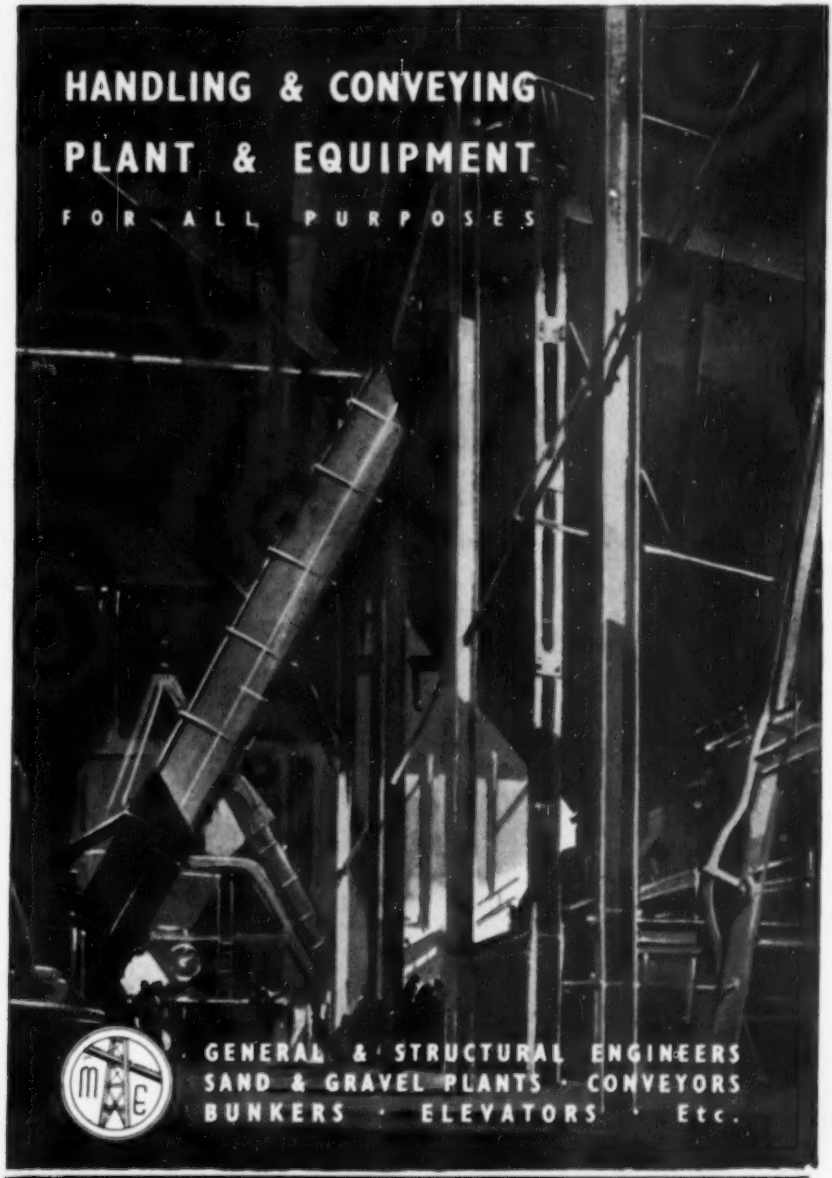
Again intermittent kilns only are used. The size of these has greatly increased from 10-15 ton to 30-45 ton capacity. The use of borax during the salting period has been introduced to facilitate glazing and to give a better finish. Some inter-connection of intermittent kilns has been practised on the Continent. In this country and America car tunnel kilns have been tried out but a number of difficulties have been met.

Fire Clay Products

The trend has been to fire a larger proportion of these continuous kilns. Belgian kilns have been quite widely used and several more have been installed recently. There are a few transverse arch chamber kilns and as explained previously there are up to twenty car tunnel kilns in use in this country. The trend is to fire high quality firebricks at high temperatures in producer gas-fired car tunnel kilns. Intermittent downdraught kilns are still largely used particularly where special shapes are produced.

Silica and Basic Products

These goods are mainly fired in intermittent kilns. Round kilns with stoker at the centre bottom have recently been introduced to fire silica goods and a car tunnel kiln fired with producer gas from coke has also recently been installed. Tunnel kilns fired with natural gas and oil are used for this purpose in America. The Shaw producer gas-fired chamber kiln has been used in this country, and semi-continuous kilns coal-fired to transverse grates have been used at one works for a number of years. Mendheim gas-fired chamber kilns and car tunnel kilns are used on the Continent for silica and basic products; in this country one kiln of similar type to the Mendheim is used to fire basic products.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PROGRESS IN THE HEAVY CLAY INDUSTRIES

by W. NOBLE, B.Sc., A.R.I.C.

AT the Building Materials Section meeting at the Palace Hotel, Buxton a paper on Progress in the Heavy Clay Industry was presented by Mr. W. Noble,* B.Sc., A.R.I.C.

Early History

Mr. Noble briefly reviewed the early history of the industry with particular reference to brick, tile and salt-glazed pipe manufacture. Although manufacture in each section dated back some 6,000 to 6,400 years, serious interest in development started mainly after the Fire of London in 1666. Taxation on bricks between 1784 and 1850 and on tiles between 1784 and 1832 restricted development to some extent and very little progress had been made in sanitation up to this time. About 1,100 million bricks were produced in 1830 however, and some 65 million roofing tiles, together with 5 million paving and other tiles. Industrial and railway developments had increased the demand for bricks to 2,000 million in 1854 and this was also the output for 1912 although nearly double this number of bricks were made in 1907, together with some 280 thousand tons of roofing tiles. Building demands had increased this output to more than 7,000 million bricks between 1935 and 1938 when the roofing tile output also reached the record figure of 980 thousand tons with a relatively stable pipe output of 600 to 650 thousand tons over the period.

Developments—1830 to 1900

Outlining progress between 1830 and 1900 the author discussed the stages leading to the establishment of the wire-cut, stiff plastic, semi-dry press and soft mud processes and showed how these processes, with developments in the use of steam power and the introduction of continuous kilns of the Hoffmann type, had enabled the industry to meet the increasing demands made upon it.

At the turn of the century the semi-dry press process was firmly established in the Peterborough area though acute teething troubles had been experienced with this process elsewhere. The stiff plastic process was similarly established in regions near the coal fields where coal measure shales provided the raw material. Hand making was still in use on most of the smaller works however. Clays and shales were being won by hand with assistance from blasting on modern works. Tubs were replacing barrows for clay transport on most works and steam haulage and overhead ropeways had been recently introduced. Hot floor dryers heated by coal, steam and occasionally by waste heat from kilns, were used on most modern works using plastic processes of manufacture, but seasonal yards with hack drying were fairly common. The first tunnel dryers had been designed and earlier types of chamber dryers were being used though development of these on controlled humidity principles took place later. Intermittent kilns including many updraught kilns were still being largely used for firing though continuous kilns of the Hoffmann and modified Hoffmann types were well established and had rapidly increased in popularity after being introduced into this country prior to 1870. They were regarded as essential at most modern works at the end of the century.

Problems of Modernisation

Mr. Noble said that, because of layout problems and the amount of capital involved some considerable lag in the adoption of new machines and processes was inevitable, in addition to the inertia to change which it was necessary to overcome. Consequently the picture of the industry in 1900 was necessarily a picture of progress during the preceeding 30 to 50 years. It might equally be said that in the present structure of the industry most of the stages of progress from the modern works of the year 1900 could be observed but account had to be taken of the limited transport facili-

* Principal Scientific Officer, Heavy Clay Division, British Ceramic Research Association.

ties, longer working hours, relative lack of amenities, and of the sparsity of literature and lack of technical background in 1900 in order to obtain a complete view of the progress made.

Mechanical Handling

He then discussed developments in the mechanised winning of clay and in mechanised handling and haulage equipment and indicated the importance to the modern works of flexible types of haulage such as small petrol, diesel and electric locomotives and motors, dumpers and small utility trucks for handling clay materials. Heavier and better grinding equipment had been introduced with mechanical feeders and proportioners and high speed differential rolls and disintegrations for fine grinding were other modern features. In considering making processes and machinery, emphasis was placed on the importance of de-airing which was now incorporated in most of the extrusion machines used for making smaller pipes in the salt-glazed pipe industry. Pug design had also altered appreciably during the period but the difficult problem of lamination was not yet solved.

Improvements in the design of tunnel and chamber dryers were outlined which together with mechanisation of handling processes had enabled labour and fuel costs to be reduced. Developments in kiln and firing practice were only briefly reviewed by Mr. Noble since they were being considered in a separate paper.

Technical Background

It must be remembered however, that up to 1900 the industry had very little technical background with no English journal prior to 1893 to foster its interests and no adequate text books. Local traditional experience, works trials and the results of chemical analysis provided its main resources. The limitations of chemical analysis in interpreting clay properties were realised and the value of works experiments was greatly restricted in the absence of practical methods for temperature measurement. The awakening of interest during 1914 to 1932, as exemplified by the literature produced during this period, by the establishment of the British Refractories Research Association in 1920 and the Building Research Station in 1921, together with marked improvement in collaboration within the industry, were important features of the period.

There was still a considerable amount of work to be done in providing the technical background necessary for the full development of the industry however, and there was a wide variety of problems which remained to be solved. These problems were considered in relation to the authors views on future trends in the several branches of manufacture, trends which must be influenced by

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high labour and fuel costs and by increased competition from non-clay building materials, including concrete tiles and pipes, foamed slag and other porous products and prefabricated materials.

It seemed evident, Mr. Noble said in conclusion, that while the heavy clay industries could look back on a considerable measure of progress during the last 50 years, the tasks ahead provided no justification for complacency. He felt that the period 1900-1950 could be regarded as representing the transitional stage between traditional and technical development. He thought it would be a worthy and profitable aim to give real technical status to the industry during the next 50 years, to ensure that clay products retained their pre-eminent place in building construction and to ensure that it attracted the type of labour and personnel which the highly technical nature of many of its operations demanded.

TECHNICAL EDUCATION FOR THE CLAYWORKER

By M. S. WHITEHOUSE

President of the Society

AFTER referring to the wide discussion on the general topic of "Technological Education" which was proceeding throughout the country, Mr. M. S. Whitehouse introduced his paper by saying that he would deal with the subject from the management angle, and primarily from the point of view of the building brick and heavy clay section with which he personally was concerned. He would not be dealing with the education of the skilled tradesman in the industry, although the latter was a most important subject which must not be overlooked. The following is an outline of his remarks.

Need for Improved Technical Education

Although technical education in the heavy clay section of the ceramic industry has hitherto been confined to works training and tradition the technical progress of that section since 1900 has been spectacular in volume, output, average quality of the article produced, and in the improvement in status and stability of the manufacturing units. This was largely due to the splendid impulse from the engineering side, and to the traditional native talent for improvisation and modification. Changing circumstances now emphasise the need for improved technical education, especially in view of four main considerations:

1. England is well endowed with suitable clay reserves, and clay is certain to continue to be the largest primary source of building materials. While it is probable that the finished article as produced at present will continue to be used for many years to come, new techniques in building will call for modification and may involve considerable changes.

2. Labour and fuel account perhaps for 80 per cent. of the cost of the finished article. The industry grew up on plentiful supplies of both, but now more labour must be devoted to export and home industries must learn to economise: coal is a national asset which must also be conserved. New sources of energy and the transmission of energy will be developed. All this will increase the pressure for the most up to date technical processes.

3. The method of getting the finished product on to the job still remains largely what it was in 1900, and must be closely scrutinised.

4. The great increase in fundamental physical and chemical knowledge will if translated into terms appropriate to the heavy clay section, of itself lead to change and improvement.

The management of the future must be able to assess and deal with the impact of these considerations, and must be able to make use of the scientific shorthand which will enable them to do so. Any man who has charge of a technical process must in future have some degree of specific technical training. By outlining a general classification of

degrees of management from the foreman upwards, it is possible to arrive at some idea of the extent of the requirement. It is suggested that generally speaking the requirements of the Pottery and Refractory section of the industry will follow the same lines, with modifications appropriate to their particular needs for specialisation. The following table gives such an outline.

SCHEDULE OF TECHNICAL MANAGEMENT STAFF IN THE CLAY INDUSTRIES WHO WILL NEED SOME DEGREE OF TECHNICAL TRAINING

Management Staff of the Industry

1. The Foreman
2. (a) The Works Manager
   (b) The Works Engineer
   (c) The Works Scientist
   (d) The Technical Salesman
3. (a) The Technical Production Manager
   (b) The Chief Engineer
   (c) The Chief Scientist or Technical Officer
   (d) The (Technical) Sales Manager
   (e) The Chief Accountant
4. The General Management

Research and Educational Staff of the Industry

5. (a) The Technical Research Scientist
   (b) The Research Engineer
   (c) The Sales Research Scientist
6. The Teaching Staff at Universities, Research Institutes, Technical Colleges, and for local lecture courses

NOTE.—Engineer and accountancy branches are included in this table for sake of completeness. They will have their own appropriate technical training in engineering and accountancy, but the engineer in particular may need additional training in ceramics.

Present Educational Facilities

A review of existing facilities reveals the following:—

Stoke-on-Trent. The North Staffordshire Technical College runs its well-known full time 3 years course in Pottery and General Ceramics for pottery managers: the course is run on the "sandwich" system (6 months at college alternately with 6 months at the works) and has been extended to include clay building materials and refractories. Part time day and evening courses and special courses on kindred subjects (including for instance costing and commercial law) are also run.

Sheffield, Leeds, Glasgow and London Universities all include the subject of Refractory Materials in their Metallurgy courses, and special emphasis to this subject is given in certain postgraduate studies and research. Leeds University has further major developments under contemplation: two other minor but important developments are:

(a) at Sheffield, a link between the University and the Sheffield Trades Technical Societies' Branch provides a vocational course on the treatment of clays and refractories.
(b) at London the Imperial College recently ran a series of open lectures on the building brick and heavy clay industries.

Other Institutions and Courses. The Searle School of Clayworking at Charlbury near Oxford has run a series of correspondence courses on the heavy clay industries and refractories for a number of years. The Stourbridge Firebrick Association has sponsored certain works practice courses at a local technical institute. The Institute of Clay Technology (London Branch) is hoping to sponsor a series of evening lectures in London shortly.

From the above it is clear that primary technical education in ceramics has been virtually confined to Stoke with, of course, emphasis on the pottery side, while undergraduate and postgraduate education has naturally centered round the centres of the steel industry with emphasis on refractories. There is a clear need for expansion to meet heavy clay sections requirements, and probably those of the ceramic industries in general.

Method of Meeting Future Requirements.

It is suggested that: (i) Training at the works must continue to play a fundamental part in the educational structure, and therefore apprenticeship must be considered as of primary importance. Apprenticeship should

be encouraged by the appropriate bodies in the industry. Apprenticeship will however need to be supplemented by some form of technical course, probably locally organised and run. This combination of apprenticeship and local course would be the main source of training for Grade (1) of the management staff (see table above).

(ii) The managers course, similar to that at Stoke, should be available to the whole of the industry, whether at Stoke only or at works centres throughout the country, as the main source of training for Grade (2) in the management staff.

(iii) It should be contemplated as a long term objective that an undergraduate degree with or without institution membership should be the main source of qualification for higher technical staff—Grades (3)-(6).

(iv) Refresher courses will be needed for all stages of management in varying degrees—Grades (1)-(4).

(v) Postgraduate study and research should be encouraged and intensified to provide training for research as well as personnel for Grades (5) and (6). Research institutes and industry itself would also supply some of this personnel.

Geographical considerations (the widespread nature of the industry) and numerical requirements (in order to avoid overstating the need) would need to be most carefully considered. Any scheme must have the full support of the industry and of the educational authorities.

In concluding his paper, Mr. Whitehouse intimated that from his experience the co-operation of the Educational Authorities would be readily forthcoming for any well founded scheme, and suggested the ceramic society might devolve the duty of calling together interested bodies throughout the industry, who he suggested might include the following:—The British Pottery Manufacturers' Federation, The National Federation of Clay Industries, The Institute of Clay Technology, The Refractories' Association of Great Britain, The Institute of Clayworkers, and The British Ceramic Research Association. He regarded the co-operation of the last named body as very important. There might be other interested bodies of whom he was not aware.

CERAMIC EDUCATION

by Dr. W. L. GERMAN

CERAMIC education in this district may be said to have originated about 70 years ago with a fortnightly lecture at the Mechanics Institute in Hanley given by Dr. Thos. Cornelly of Owens College, Manchester. This dealt with the chemistry of pottery processes. A regular class on the manufacture of pottery was begun in 1884 by Mr. Miles Knowles, and a year later a similar class was begun at the Wedgwood Institute by Mr. S. J. Harris. In this institute, for the first time, a series of practical classes to illustrate the subject matter of the lectures was inaugurated; and was very successful.

In 1899 the Victoria Institute, Tunstall, became the centre of instruction with a specially fitted laboratory. Mr. W. Jackson was appointed instructor to the pottery classes. Here began a series of investigations into problems connected with the industry, and a series of discussions led to the formation of the north Staffordshire Ceramic Society, the forerunner of the British Ceramic Society, whose Jubilee we are celebrating. Mr. Jackson took up a commercial appointment in 1904, and a year later Dr. J. W. Mellor was appointed lecturer in ceramics at the Pottery School, which 3 years later was moved to a corrugated iron building on the site of the present Technical College in Victoria Road. This building, incidentally, is still in use. When the new Technical College was built in 1914 the Pottery School was housed in more extensive premises. Dr. Mellor continued Head of the Pottery School till his retirement in 1934.

Co-operation with Industry

He gained a world-wide reputation as a teacher in ceramics, and founded

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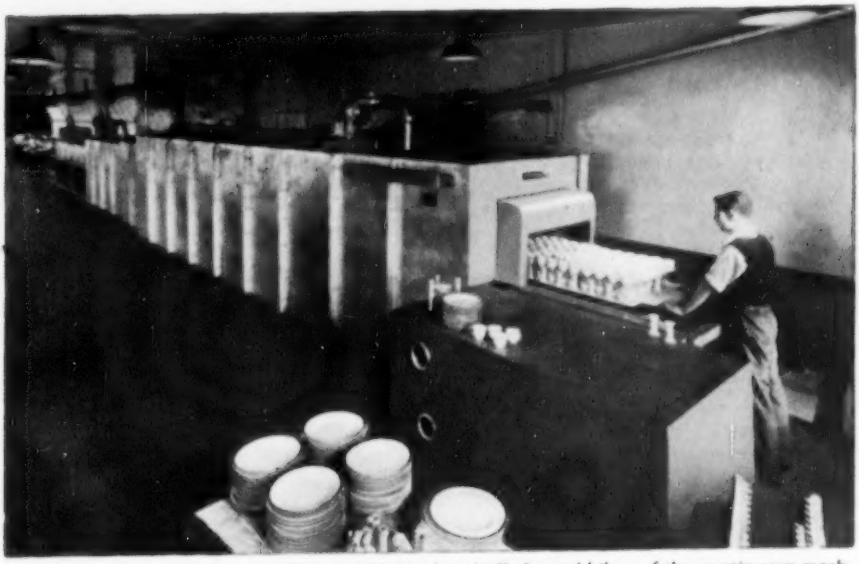

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that close co-operation between the industry and the College which exists to the present day and which we hope will long continue. The considerable story of his scientific achievements has been told elsewhere. He was outstanding in encouraging students to develop a critical mind, and to test ideas with practical experiment. In this way rule of thumb methods and the guarding of "trade secrets" was outmoded.

On his retirement in 1934 Dr. H. W. Webb was appointed the first Principal of the Technical College and Head of the Pottery Department. He had had considerable experience of the application of research to industrial production, and under his direction the practical side of the training has assumed increased importance. The courses have been enlarged by the introduction of training in those subjects necessary to equip a pottery manager for management such as Industrial Accounts, Personnel Management, Sales Organisation, etc. In addition a series of lectures on modern trends of production are given by experts from the industry. The College Managers Certificate, which is only awarded to those whose practical experience in the industry as well as theoretical knowledge is satisfactory, has attained a world-wide reputation. He also enlarged the scope of the full-time day course in ceramics and modelled it on the "sandwich" principle—namely 6 months practical experience in the industry and 6 months training at the College each year. The success of this is illustrated by the fact that students from all over the world now apply for admission to the course.

Trends Towards Mechanisation

The present trend towards mechanisation has resulted in increased attention being given to engineering as part of the students training. On the pure ceramic side, in addition to having to reach a high standard in theoretical knowledge, the student is trained to locate the faults in making, mould making and decorating which lead to losses in production. For this purpose workshops with full-size machinery have been installed at the College.

The College also offers similar training on a part-time basis.

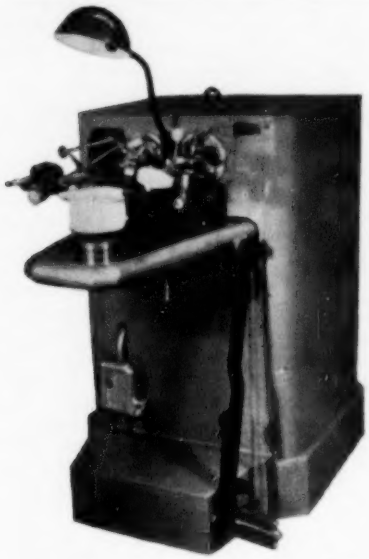
Believing that the education of operatives is essential to the progress of the industry a scheme for the training of new entrants to the industry was drawn up with a properly equipped training centre. Owing to post-war building restrictions it has not yet been possible to proceed with this scheme, which is to be linked with a proper apprenticeship scheme for the industry.

For some time now the accommodation at the College has been taxed to capacity and further expansion of ceramic education awaits the provision of new buildings. It is hoped that these will be started next year, when it is believed that with the improved facilities available ceramic education will take another big step forward.

THE UNIVERSITIES AND CERAMIC EDUCATION

PROFESSOR A. L. Roberts, of the University of Leeds (Livesey Professor and Head of the Department of Coal Gas and Fuel Industries, which includes a Ceramic Section) first referred to the general question of the place of technology in universities, a matter which had been widely discussed nationally during recent months. Everyone was agreed on the urgent need for more technologists in British industry; the outstanding questions were the type of training best suited to produce men of the right calibre and outlook, and the facilities for giving such training.

Many universities had Faculties of Applied Science or Technology with a long experience of training technologists. The British system of training graduates in technology could be claimed to produce men of the highest calibre; it consisted in giving the men sound preliminary training in



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pure science and engineering followed by systematic instruction in applying that science to specific industrial fields. This was the true technologist, the man who approached his subject through the study and application of the underlying science and not by first learning the operating technique.

Use Existing Institutions

A proper function of the university was to train the technologist, and it was essential that existing universities should receive all the necessary support to produce this type of men in adequate numbers. He considered that there was no general case for the establishment of new technological institutes nor for dissociating technological departments from the universities. He felt that full provision for increasing the output of technologists could be made by expansion of the universities, which could be done without upsetting their balance. New technical colleges might prove necessary in certain cases to meet increasing demands, but he pleaded for the fullest examination of the present facilities and for strengthening and supporting well-tried existing institutions before instituting new ventures.

With regard to university technological training in ceramics, facilities had long been available at certain universities for post-graduate study and research and for a certain measure of undergraduate teaching. At the moment however, there were no facilities for first degrees in ceramic technology—in marked contrast to the position in U.S.A., where some 250 graduates are produced annually. In his opinion degree courses were urgently required, particularly because the needs of the industry would not be met by men with post-graduate qualifications, even if they were available in sufficient number.

Proposed Degree in Ceramics

He had therefore proposed to the University of Leeds that a course leading to the degree of B.Sc. with Honours in Ceramics should be instituted forthwith. The course would cover 4 years following matriculation; the first 3 years would largely be devoted to science and engineering subjects (although the student would be progressively introduced to his specialist subject), and the 4th year would be concerned solely with ceramics. The proposals had passed the first stage of acceptance but still had to be ratified by Senate and Council of the University; he was hopeful, however, that the measure would be accepted and that the new course would become operative as from October, 1950. Whatever its shortcomings, the course would represent an attempt to give full academic status to ceramics and to provide a steady supply of ceramic technologists for entry into the industry. He hoped also that other universities would see their way to offer similar facilities in due course.

POTTERY WAGES

A PRIVATE hearing opened recently in the Stoke-on-Trent Town Hall concerning the arbitration in the pottery industry for settlement of proposed adjustments to the wages structure. The hearing was before Mr. E. G. Honeyman, chairman, Mr. G. M. Hann and Mr. W. E. C. Lazenby. There had been an exchange between the British Pottery Managers' Federation and the National Society of Pottery Workers in February within the orbit of the National Joint Council, and failing to reach agreement, the questions at issue were referred to arbitration.

The National Society sought twelve days' annual holiday with pay, instead of six as at present; an increase in minimum time rates for all females and the lower paid male workers; and higher pay for statutory holidays.

The Federation's proposal concerned the arrangement in regard to the settlement for work performed and the payment of wages.

An official statement has now been issued, signed by the joint secretaries representing the operatives and employers of the National Joint Industrial Council.

New minimum rates will apply in the settling week next following 21st April. New weekly rates for juveniles have been introduced and the Councils agreed with the change-over to the week-in-hand system being completed by mutual agreement between the management and the operatives of each works within a maximum period of eight weeks if so desired by the operatives, starting with the pay day of Friday, 5th May, 1950.

Some Observations on Bone China

by

W. L. GERMAN, M.Sc., Ph.D., F.R.I.C.

Origins of China

THE manufacture of porcelain originated in China under the Tang dynasty (A.D. 618-907) and at the time of the Ming dynasty (14th-15th Centuries) porcelain acquired that quality which made it world famous.

It was brought to Europe by Arab traders in the 12th Century, but it was the voyages of Marco Polo that established definitely its place of origin as China.

Chinese porcelain was of such beauty that it was highly prized, and attempts to reproduce it in Europe were made by many princes. Success was achieved by Friedrich Böttger at Meissen in 1709 in the castle of the King of Saxony.

Elaborate attempts were made to preserve the secret of the art, even to the extent of imprisoning the potters in the feudal castles, but, as was inevitable, the secret leaked out and porcelain was eventually made in other European countries.

It was first made in France at Vincennes in 1740, and the manufacture was later transferred to Sevres. The original Chinese porcelain was made from kaolin (china clay) and a pegmatite (pe-tun-se), but the early French porcelain used a glassy frit instead of felspar as a flux. After 1770 the French made the true porcelain similar to the Oriental and German types.

Introduction of Bone Ash

There was as yet no use of bone ash as an ingredient of a translucent body. The manufacture of porcelain started somewhat later in England. In 1745 a porcelain was made at Chelsea and also at Bow. In both these early types, a glassy frit was used on the pattern of the early French ware (the "soft-paste" porcelains). These mixtures were difficult to work and experiments were made with various additions to produce workability and whiteness. In 1749 Thos. Frye of the Bow works patented the use of bone ash, and it was subsequently used there, and at Chelsea. It was not the bone china as we know it now, for a glassy frit was still used. The change to the present mixture of china clay, bone and stone is attributed to the younger Spode about 1794. His innovation in dispensing with the use of the glassy frit paved the way for the modern manufacture of bone china.

The use of frits was not abandoned completely and about 1840 a body called Parian was invented in Stoke. This employed flint glass as a flux. It is interesting to note that this and other innovations, such as the use of soap-stone, have disappeared, and that with about one exception, British table porcelain is now entirely a bone china body.

Literature on Bone China

The beauty of the bone china body, with its soft translucency and gleaming whiteness excites universal admiration. It is surprising however, to note how little is known about this ceramic body. A survey of the literature of the subject reveals a surprisingly small number of published papers on the subject. These deal with the following main aspects:—

(a) the role of bone in the body;
(b) the colour of the body;
(c) the effects of firing conditions;
(d) translucency.

Effect of Lime in the Body

H. E. Wood (*Trans. Brit. Ceram. Soc.* 1.21.1901-2) concluded that free

lime in the bone acted as a flux, and bleached the yellow colour developed by iron in the body mix. Of the bone ash itself he concluded that it remains as $Ca_3(PO_4)_2$ dissolved in the silicate in the body without interfering with translucency, whitens and lightens the body, and prevents squatting.

W. Jackson and A. D. Holdcroft (*ibid* **4**.6.1904-5) concluded that bone additions act as a flux up to a certain point and thereafter the excess acts as a refractory. Seventeen per cent. of bone in the body gave the greatest fluxing effect, which is due to the formation of a lime alumina silica glass $CaO.Al_2O_3.4SiO_2.[\frac{1}{2}P_2O_5]$.

Use of Substitutes

From time to time experiments have been undertaken to determine whether substitutes could be used in place of bone, which was in short supply in war time, and is perhaps equally difficult to obtain now. Mineral phosphates, such as apatite, have been used. While in some cases the colour and translucency were good, there was trouble in firing due to deformation (cf. N. B. Davies, *Trans. Amer. Ceram. Soc.* **19**.125.1917).

There is no doubt that earlier experiments in the use of mineral phosphates, and of pure calcium phosphate in place of bone have suffered from two uncertainties:—

(a) no control of the grain size of the ground material was undertaken;
(b) firing was subject to the uncertainties of the intermittent oven.

Suggested Series of Trials

It would be interesting if a series of trials could be undertaken using bodies made with pure calcium phosphate of controlled grain size, and fired in a tunnel oven, to establish whether there is any particular physical property of ground bone which makes it superior to pure calcium phosphate in china bodies.

If these proved that it were possible to use a substitute for bone ash it would undoubtedly ease the supply position for the principal ingredient of the bone china, and would make it possible to control more readily the addition of calcium phosphate in the body. Carbon brought in with the calcined bones would also be eliminated.

The Colour of the Body

A detailed study of the effect of variations in the composition of the body on the colour of the fired ware was published by W. H. Yates and H. Ellam (*Trans. Brit. Ceram. Soc.* **17**.120.1917-18 cf. also J. W. Mellor *ibid* **18**.497.1918-19). The surprising fact emerges that it is possible to vary the colour of the china from yellow, through brown, to green simply by varying the proportions of the ingredients in the body. This is brought out very clearly in the table which is extracted from Dr. Mellor's paper.

TABLE I

Variations in the colour of bodies prepared by firing mixtures of bone, stone and china clay to the same temperature.

Composition			Colour
% china clay	% bone	% stone	
60	20	20	light brown
40	40	20	pale green
40	20	40	yellow
20	60	20	colour very slight
20	40	40	ditto
20	20	60	ditto

The original paper should be consulted for the full results, which include a triangular diagram showing the effect of variations in the body composition on the fired colour. The actual range of compositions which gives a white body is a narrow one, and there is a bigger margin of safety with variations in the proportion of bone than with either stone or china clay. Thus a change in the type of stone used may be sufficient to alter the body composition so as to produce a body tending to a bluish colour. A variation in the water content of the stone, if undetected, may also so alter the body mixing that blue china results. Similar results can follow from variations in the water content of the china clay.

Conditions for "Green China"

Dr. Mellor (loc. cit.) was also able to show that green china could be produced by reducing atmospheres or the presence of carbon in the body when fired. The explanation offered was that the iron in the body reacted with the phosphate to form a kind of ferrous phosphate analogous to the mineral vivianite, which is blue. This subsequently turned brown in the enamel kind, or on long standing.

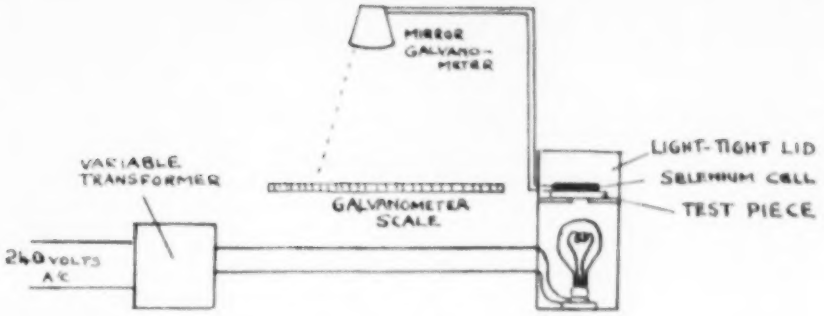

Fig. 1

due to oxidation, and gave the phenomenon of "brown" china.

Thus we have two sets of conditions which can give "green" china, one involving firing under reducing conditions, and the other where they are oxidising throughout. Moreover it is possible to get green china with bodies containing much less carbon than those which do not give the fault. Evidently neither explanation satisfies all the observed facts and a complete explanation of green china is another research problem to be tackled in connection with bone china.

Effects of Firing Conditions

One effect of firing conditions has already been mentioned, the formation of green china in reducing atmospheres. The margin of safety in firing bone china is less than with other bodies since the maturing temperature is near that at which the body softens, and some support is usually required for the ware. Overfiring causes bloating, and Dr. Mellor noted a smell of phosphorus on separating two boxed cups which had been overfired and were stuck together. He pointed out that this could have been formed by the action of silica and carbon, or a reducing atmosphere, on the calcium phosphate such a reaction being used for the commercial preparation of phosphorus. Phosphorus vapour is then a possible cause of the bloating of bone china.

Translucency of Ware

Translucency is the distinctive property of all porcelains and gives them their attractiveness. We frankly do not know exactly what causes the translucency—this is another of the uncertain things about bone china. The various attempts of microscopic examination have given rather inconclusive results (cf. H. B. Cronshaw, *Trans. Brit. Ceram. Soc.* **17**.153.1917; A. A. Klein, *Bur. Stand. Tech. Paper* No. 80, Dec. 1916).

Latterly W. A. Weyl (*J. Amer. Ceram. Soc.* **24**.245.1941) has postulated that the body consists of a rigid framework of fluorapatite and hydroxyapatite, filled with a glass high in lime, and having a higher refracture index than the normal glassy matrix found in other porcelains.

J. W. Mellor (*Trans. Brit. Ceram. Soc.* **5**.79.1905-6), arguing by analogy with the translucency developed by blotting body when it has soaked up grease, considered that translucency is developed when the china clay soaks up molten felspar. A course grained clay like china clay would find this easier than a fine grained one like ball clay and it is found that additions of more than about 2 per cent. of ball clay impairs translucency. Possibly the new methods of microscopy based on the electron microscope may help in elucidating the ultimate structure of bone china.

Measurement of Translucency

Since the body is prized for its translucency it is not surprising to find in the literature descriptions of pieces of apparatus designed to measure this property (cf. F. C. Arrance, *J. Amer. Ceram. Soc.* **25**.116 1942.; N. L. Haldy, J. H. Wright and

F. C. Todd, *ibid* **30**.153.1947; C. Atkins British Pottery Res. Assocn. Confidential Technical Paper No. 56). For works control the method most widely used in this country is to observe the shadow of fingers held against the ware when placed between the eye and an artificial light. For research purposes something more precise is needed, and a simple type of apparatus would undoubtedly be useful for works control in manufacture. Such an apparatus will be described later in this article.

Earlier investigators employed adaptations of photometric methods, such as observing the smallest size of wire mesh that could be seen when placed behind the illuminated object and viewed from the other side (cf. C. Wheelans and H. E. Ashley, *Trans. Amer. Ceram. Soc.* **13**.102.1911). A wedge method, involving measuring the thickness of ware which would just block out the light from a suitable light source was also used (H. E. Ashley, *ibid* **8**.147.1906 and L. Ogden, *ibid* **13**.400.1911). Numerous other methods employing photometric methods have also been described (cf. I. G. Priest, *ibid* **17**.150.1915; W. Steger, *Ber. Deut. Keram. Ges.* **2**.9.1921, **2**.63.1921; **3**.50.1922; R. Riecke and K. Samson, *ibid* **6**.189.1925; C. W. Parmelee and P. W. Ketchum, *Eng. Expt. Stat. Univ. Illinois Bull.* No. 154, April, 1926).

Photoelectric Cells

All these devices suffered from the fallibility of the human eye, and with the development of the photoelectric cell it was not surprising to find that it tended to supercede other methods of comparing light intensities. The photoelectric cell is briefly a device which generates a small electric current when exposed to light. The current is proportional to the light intensity.

An apparatus of this kind was first used on ceramic materials by C. W. Parmelee and R. E. Lawrance (*J. Amer. Ceram. Soc.* **6**.630.1923) using a photo cell of the potassium type, and improved pieces of apparatus are described by Parmelee and Ketchum (loc. cit.) and R. Riecke and A. Ungewiss (*Ber. Deut. Keram. Ges.* **17**.237.1936) and later by F. C. Arrance (loc. cit.) and Haldy, Wright and Todd (loc. cit.) and C. Atkins (loc. cit.). Two difficulties arise in using photocells for comparing translucencies:

(a) the cells of the valve type are expensive;
(b) with increasing thickness of ware it is often necessary to add an amplifier—an added complication and expense.

For routine control of factory production something simpler is needed. Again the translucency varies with the

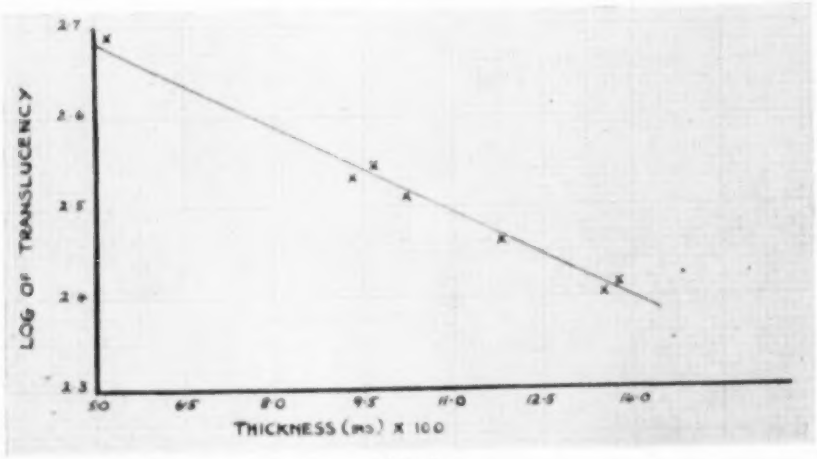

Fig. 2

thickness of the test piece, and it is very difficult to produce them to a standard thickness. This being so, it is necessary to correct for the thickness.

Use of Selenium Cells

The following apparatus, which was used for some laboratory trials on bone china, may be of interest for routine trials on controlling the translucency of mass-produced ware.

A simple cheap selenium cell was obtained from Salford Electrical Instruments Ltd., Salford, and connected to a sensitive Cambridge Ayrton - Mather galvanometer fitted with a lamp and scale. This gave a deflection of 200 mm. at 1 metre from the galvanometer for a current of one micro ampere in the photocell circuit. The resistance of the galvanometer was approx. 25 ohm. The light source was a 100 watt electric lamp enclosed in a wooden box, blackened inside and louvred to disperse heat. The light emitted could be varied by connecting the lamp in series with a Variac type 100-L variable transformer supplied by the Zenith Electric Co. Alternately an iris diaphragm could be fitted in the aperture dividing the upper and lower parts of the light-proof wooden box (Fig. 1).

To standardise the apparatus a standard bone china test piece (about 2 in. × 2 in.), or a piece of opal glass is placed in the upper part of the box and the selenium cell placed in contact with it. The light in the bottom of the box is switched on and by adjusting the diaphragm in the box, or the transformer in the lamp circuit, the scale deflection is brought to a convenient place on the scale. Usually a thin test piece was used, and the scale deflection adjusted to give a reading at one end of the scale. The thicker test pieces were then put in place of the test piece, keeping the lamp illumination constant and the corresponding deflections noted. To avoid fatigue in the cell the lamp is cut off while the test pieces are being changed. At the end of the determinations the standard test piece is put in again to make sure that the light intensity has not changed. If it has, the apparatus is restandardised and the readings repeated.

Test for Average Thickness

The average thickness of the test pieces are then determined with micrometer readings taken at various positions on the pieces. Should the test pieces be not absolutely flat it is as well to take translucency readings with both sides in turn facing the lamp. Using this simple apparatus no difficulty was experienced in getting adequate differentiation in the translucencies of pieces, even when the differences in thickness were not great. It now remains to correct for the varying thicknesses of the test pieces. C. Atkins (loc. cit.) and F. C. Arrance (loc. cit.) have shown that this is governed by an expression of the type:

$\log I = \text{constant}_1 - t \cdot \log \text{constant}_2$

where I is the intensity of light transmitted by a specimen of thickness t. In other words a plot of the logarithm of the light transmitted against the thickness of the samples gives a straight line. A typical example is shown in Fig. 2, which was obtained by plotting the logs of the galvanometer scale deflections against the corresponding average thicknesses of the test pieces.

Having constructed such a graph, then, provided the body is not varied, all that is required for routine checking of translucency is to put the standard test piece into the apparatus, adjust the light to give the same scale deflections on all ocasions and then put in the test piece or pieces and measure the corresponding scale deflections. If the logs of the deflections are then plotted against the average thicknesses it will be seen that they should lie on the straight line already drawn. If the translucency has altered they will not do so, but will lie on some other straight line.

Such an apparatus is simple to assemble and use and the determination can be made rapidly.

Tile and Fireplace Association.—Good progress is reported in Scotland from the Scottish Tile and Fireplace Association. Meeting at Perth last week the Association decided to extend membership in the Border and South-West area with a view to increasing the usefulness of the body. Membership is increasing and satisfactory negotiations have been carried out with various trade organisations.

New Design High Temperature Natural Draught Furnace

by

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B.Sc., F.R.I.C., M.Inst. Gas E., A.M.I. Chem.E.
North Thames Gas Board

A HIGH temperature zone can be attained in a variety of ways, two major methods being the use of air blast burners and natural draught low pressure gas. The former is of value in industrial operations where high heat input is required, e.g. successive melting of charges of metal. In these circumstances compressors or blowers for an air supply are usually available and a certain amount of noise can be tolerated since other steps in the process may, in any case, be noisier. Where undue noise is undesirable, for instance in a Research Laboratory, then natural draught low pressure gas is necessary.

Here, the problem can be considered from two viewpoints. A famous organisation like the National Physical Laboratory may require a high temperature and this because of the importance of the problem, may be by far the dominating factor. Then apart from economic considerations, it may not matter if the furnace takes a

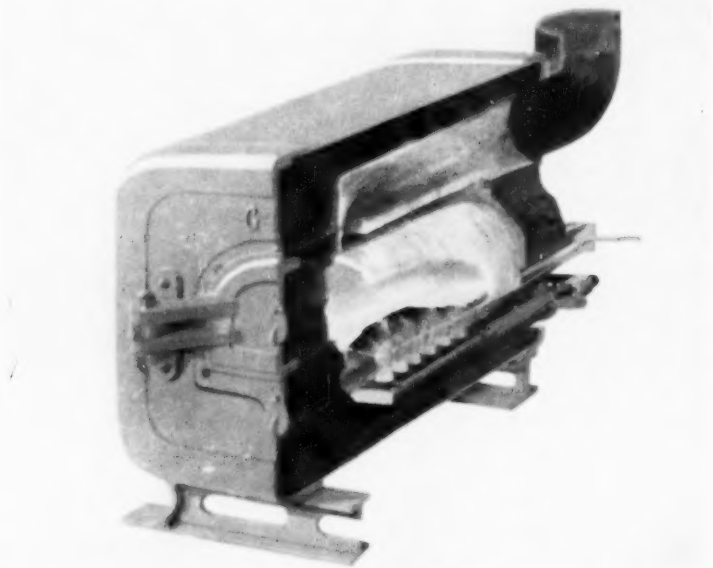

Fig. 1. Showing substitution of refractory nozzles for heat resisting steel

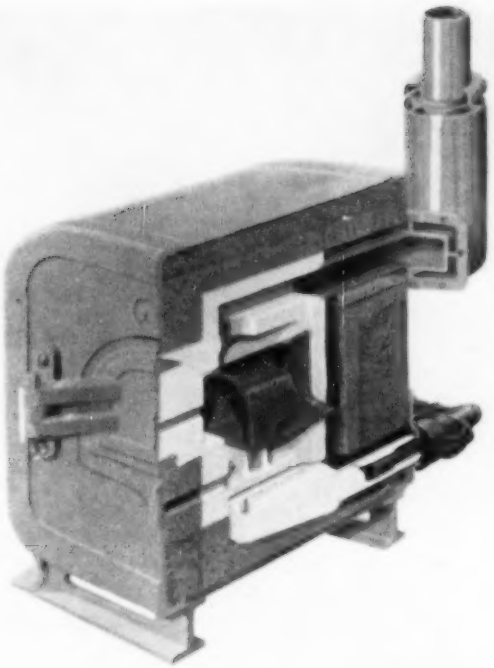

Fig. 2. Showing design of first furnace

week to heat up providing the result is, say, a uniform and accurately controlled temperature.

On the other hand, workers in the fields of metallurgy, ceramics, atomic energy or other sciences may still need the same high temperature but with the important difference that they need an operation in one shift or one day. Thus, a muffle furnace of appre-

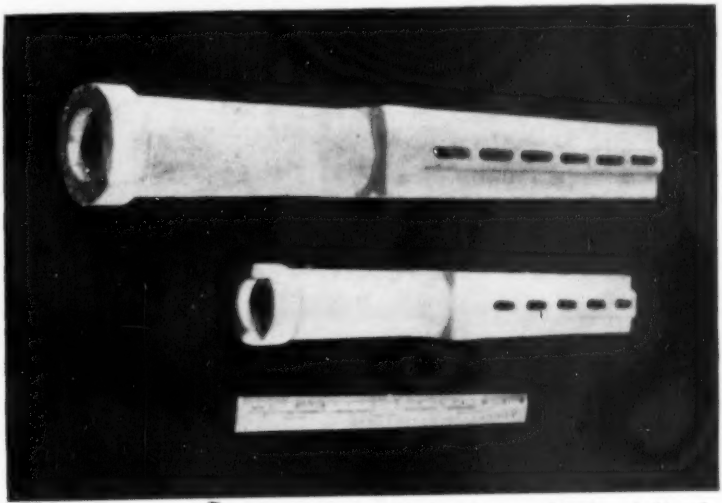

Fig. 3. All refractory burners for No. 5 size furnace (top) and No. 3 size (bottom)

ciable size may require to be heated up to 1,450° C. in about 4 hours, used and then turned out to cool overnight.

The design of a quick heating up furnace is entirely different from a slow heating up furnace. There are many refractories of high thermal capacity which will stand high temperatures with ease, as those who have experiences of carbonising or steel works will know. There are not as many refractories, however, which possess a low thermal conductivity, low heat capacity and therefore, ability to heat up quickly, together with a high resistance to the strains set up by rapid cooling. The last is a point that is often overlooked because the furnace under discussion will cool down nearly as quickly as it heats up.

The purpose of this paper is to describe the design of a furnace to fulfil the last named requirements. Experience has shown that this is one of the most difficult problems to overcome. There is, however, undoubtedly a demand for such a furnace. The starting point was the well-known range of G.L.C. furnaces of the "B" type, that is, designed to operate at a maximum temperature of 1,250° C. Fig. 1 shows a pictorial strip drawing of the "B" type.

The original design employed a burner with heat resisting steel nozzles firing into a combustion chamber made of fireclay insulating material which extended to the outer edge only, one course of bricks being used. The muffle was of silicon carbide. A subsequent modification was the substitution of refractory nozzles for heat resisting steel as shown in Fig. 1.

The original requirement was to produce a furnace of equivalent size to the G.L.C. range with a maximum temperature of 1,350° C. to be attained in three hours. Elevating the maximum temperature from 1,250° to 1,350° C. or more is not merely a matter of increasing the gas rate, a method, the fallacy of which dies hard. At these temperatures heat resisting steel only survives for a short while and some fireclay insulating bricks melt or disintegrate.

The objective of fulfilling the requirements without any increase in gas consumption compared with the "B" type furnace suggested recuperation as one modification; the other important modification was the provision of superior insulation.

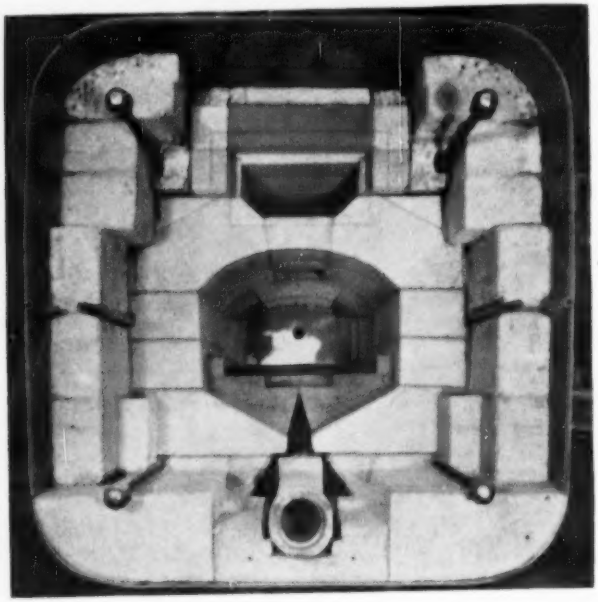

Fig. 4. Showing stage in the construction of the No. 5 size prototype furnace

This is only a short paper and it will be necessary to pass over the many interim stages and problems, not the least of which was the provision of insulating refractory bricks of the required quality since the production of such bricks is really only just beginning.

Design

Thanks to the help of the makers of the refractory bricks and muffles and to the fundamental work of the British Ceramic Research Association, we can now say that the objective has been attained and a furnace has been made in which a maximum temperature of 1,450° C. can easily be reached.

refractory which so far seems to be standing up to the arduous conditions, one of which is that the top surface of the burner is exposed to direct radiation from the combustion chamber which must attain a temperature of at least 1,500° C.

It is possible the design may have to be modified to reduce the thickness of the sections wherever possible and minimise cracking.

Fig. 4 shows a stage in the construction of the No. 5 size prototype. It is apparent from this picture that a tribute must be paid to the craftsmanship in such work because a badly made joint increases the heat losses through the brick courses and may vitiate the test results. In produc-

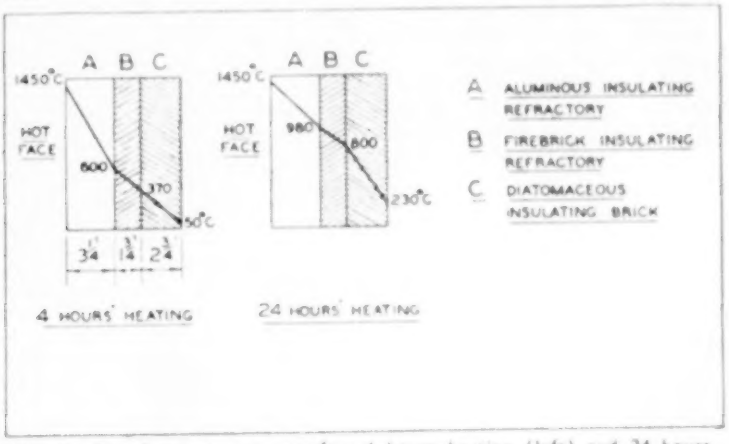

Fig. 5. Showing temperatures after 4 hours heating (left) and 24 hours soaking (right)

This furnace, the first design of which is shown in the pictorial strip drawing (Fig. 2) has a simple heat resisting cast-iron recuperator which, with a silicon carbide box as a heat exchanger, succeeds in raising the secondary air temperature at the burner to about 600° C. A high quality aluminous insulating refractory brick is backed with fireclay insulating refractory and an outer course of diatomaceous bricks.

The problem of a suitable burner at the high temperature prevailing has already been mentioned. All refractory burners have been developed successfully, one of which is seen in Fig. 3. The larger burner is for the No. 5 size furnace, the smaller for the No. 3 size. The material is alumina

tion, moulded sections would be used where possible but this is not economical or practical in the development stages.

Performance

It was decided to concentrate on the No. 3 and 5 sizes of the G.L.C. furnace range and Table 1 gives details of the dimensions.

The figures on Table 2 illustrate two important points.

1. In spite of an overall increase in size of the high temperature furnace, the heating up rate compared with the "B" range has been maintained with a considerable reduction in initial gas rate. This is due to superior insulation.

TABLE 1

Furnace Size	Max. Temp. °C	Overall Dimensions Width ft. in.	Height ft. in.	Depth ft. in.	Muffle Size—Internal Width in.	Height in.	Depth in.
3	1,250	1 7	1 9	2 1 3	5	3½	8
3	1,450	2 0	2 3	2 7 3			
5	1,250	2 3	2 6	2 11 6	9	5½	12
5	1,450	2 4	2 10	3 4 3			

Table 2 gives comparative performance of the "B" range at 1,250° C. and the high temperature furnace at 1,450° C.

TABLE 2

Size	Furnace Max. Temp. °C	Gas Rate c. ft./hr.	Approx. Time to Reach 1250°C h. min.	1450°C hr. min.	Approx. Gas Rate to Maintain 1250°C c. ft./hr.	1450°C c. ft./hr.
3	1,250	100	1 30	—	90	—
3	1,450	80	1 15	3 50	45	60
5	1,250	220	1 50	—	195	—
5	1,450	140	1 50	4 0	75	85

2. Whereas in the "B" range the gas rate for maintenance at 1,250° C. is about 90 per cent. of the full-on rate, in the high temperature furnace it is only about 50 per cent. of the full-on rate. This is due to a combination of the necessary superior insulation and air preheating.

A lack of design data on high temperature furnaces limited progress in the past. There is a conspicuous lack of information in the published figures for thermal conductivity which at the moment, are quoted only for a mean temperature of 500° C. The work of the British Ceramic Research Association[1] and the British Refractories Research Association before it, has shown that thermal conductivities change with increasing temperature (the thermal conductivities of some materials diminish with increasing temperature, but, in general, the thermal conductivities of high alumina materials increase).

Work on the influence of the pore size on thermal conductivity[2] also, together with the above, suggests that the thermal conductivity of the high alumina insulating refractory bricks in use will be approximately doubled at a mean temperature of 1,200° C.

The need for fundamental figures at this temperature and above has been repeatedly stressed and it is very gratifying to see the excellent work of the B.C.R.A. in extending the range of measurement of the existing apparatus for thermal conductivity determinations.

The measurement of the temperature between the courses of the high temperature furnace has been carried out and for the first time, it is believed, such figures are being reported.

Fig. 5 shows the temperature after 4 hours heating on the left and after 24 hours soaking on the right. It will be seen from the curve on the right that the mean temperature of the insulating refractory brick is about 1,215° C. and the striking effect of insulating refractory bricks as heat insulators is seen in the left hand curve where the hot face temperature is already up to 1,450° C. but the temperature of the outer face has only just begun to increase.

It is hoped that this furnace will be the last of its kind to be designed by a combination of experience and intuition. The ideal is to be able to design a furnace from fundamental information. Studies of two-dimensional flow in a model of the furnace described above have given promise of substantial improvements and there is not the slightest justification for assuming that the limit of temperature or performance has been reached for low pressure natural draught town gas-fired furnaces.

Thanks are due to the North Thames Gas Board for permission to prepare and present this paper.

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(*Paper to the London and Southern Junior Gas Association, 10th March, 1950.*)

American Commentary

New Ideas and Technical Developments

A STAFF REPORT

OTHER welcome wares besides Marshall Aid, tourists and Danny Kaye come to us across the Atlantic, not the least being new ideas and technical development.

It's a good thing to hear about the other fellow's ideas and opinions—of his successes and failures. Our own problems may not coincide exactly with his. We may not agree on this point or that, but a chance remark made in the light of his particular experience may give us the first vital clue in the solution of that problem which has worried us for years.

With this thought in mind, we have selected from this month's American mail bag, a few such items which we feel likely to be of interest to our readers.

SINGLE COAT ENAMELLING OF DOMESTIC COOKERS

First things first! So pride of place goes to news of a Westinghouse development in the enamelling field.

A favourite pipe dream of the enameller has long been that of the direct application of cover coats to steel and the elimination of the traditional ground coat. It would appear that the Westinghouse folk have transformed the dream into cold and effective reality! The story of that transformation provides some tasty food for thought.

The first step was to select a suitable component to act as a guinea pig for the development engineers, and that the final choice fell upon the heater platform was for the following reasons:—

1. Inherently high dollar value.
2. Sag resistance requirements both in enamelling and operation.
3. Vulnerability to damage in assembly and in use.
4. Acid and abrasion resistance requirements and general overall appearance.
5. Thickness measurements of a wide range of such platforms showed an average thickness at the highest point of 0·24 in. (pre-war) which in itself formed a strong case for lowering thickness.

The first test batch was processed in May, 1947. Pickling was done on an improvised plant in order to deposit 05 grm. of nickel per sq. ft. of steel. Titanium enamel was applied at 30 grm./sq. ft. and fired at 30-40 degrees higher than normal (laboratory tests previously made indicated a need for this).

Reports on the finished articles revealed:—

1. Excellent resistance to chipping under a 70° twist at 004-008 thickness as compared with ground coat-plus-zirconium which failed at 45° with 016 in. thickness.
2. Colour was too creamy, due to increased temperature.

The next batch was treated in September, 1947 and on the first run only 5 per cent. were satisfactory. However, the results after only spotting rejects were of the order of 92 per cent. correct. Results indicated that rejects were of a controllable nature and not caused by the steel or enamel.

Superior Appearance

The general appearance of the platforms was superior to that of previous standard productions; finish being smoother, gloss higher and texture better. Thickness ran from 005 in. on flat surfaces to 010 in. on rear corners. In fact a sawn section through the flat looked very like paint as regards thickness. Surface defects and scratches on the steel showed up and were magnified by the otherwise excellent coating. This fault has only recently been remedied but long before this achievement

rearrangements were made in the pickling plant to include a nickel tank and filter section, all ware being nickel coated irrespective of its ultimate finishing treatment.

Unfortunately the frit suppliers were at first unable to develop a frit that would burn down with regular ware and a special firing was required for the process. Consequently, less than 500 items were handled in 1947.

In March, 1948 a field check of titanium enamel on titanium steel showed:—

1. All in excellent condition and bearing high resistance to abrasion when in use.
2. Customers praised the ease of cleaning, resistance to damage and the high lustre.
3. No damage was found at heater openings.
4. Showroom appearance was preserved after six months service.

As the frit companies had not made sufficient progress in developing a frit to fire the direct-on-steel cover coat along with the regular standard ware, efforts were concentrated during the next few months on processing of samples and improvements to methods in the shops.

It was during this period that a number of specifications were drawn up most of which are still in effect at the present time. They are as follows:

1. The stamped side of steel sheet only to be used for finished side of product.
2. Maximum safe thickness limits set at .012 in.
3. Braces or clips spot welded to the underside of finished surfaces to be avoided on account of their detrimental effect on the finish.
4. Critical inspection for surface defects to be carried out before spraying.
5. Extra care to be maintained in cleaning prior to spraying in order to ensure good adhesion.
6. Control of nickel deposit at 0.8-0.12 grm. per sq. ft.

Increased Nickel Deposit

It should be noted that by now it had been found desirable to increase the nickel deposit (originally .05 grm. per sq. ft.) in order to ensure best possible adherence.

The nickel coat was found to be critical and a most important rung in the ladder to success. Accordingly, Westinghouse employed a chemical control operative whose duties included:—

(a) Hourly control checks on pickle plant.
(b) Maintaining solutions at correct concentrations and levels.
(c) Control of temperature and the checking of filter tanks for efficient operation.
(d) Making of nickel coat samples for laboratory tests (one per shift).
(e) Selection of enamel test samples for analysis and adhesion tests.

April, 1949 saw the arrival of the final frit enabling the company to start full production on "Tri-enamel steel" using their standard time/temperature cycle. Subsequent records present the following picture:

Additional Standard Items Coated By The Process

1. 100 ranges complete in all parts.
2. 200 food compartments.
3. Five crisper pans in .025 steel.
4. Laundromat front tubs.
5. Water heater tops.

Results of these samples indicate that the process is adaptable to most existing designs and methods. Further, it is suggested that the possibilities are even greater when the designer starts from the drawing board using full advantage of the properties of this combination of steel and enamel.

Production Figures

The production record on heater platforms is as follows:—

1947	500
1948	61,000
1949	150,000

Production is now nearing the 200,000 mark.

Average enamel thickness now stands at .0065 in. which represents a reduction of almost 75 per cent. on pre-war figures. It would seem the process has quite a future in the realm of vitreous enamelling!

THE TRUE-JOINT TILE

A product bearing this name has been patented recently by Gladding, McBean & Co. of Los Angeles, California. Like all good ideas it is

so simple the the observer is left wondering, "Why didn't I think of that?"

Briefly, it is a tile bearing two $\frac{1}{8}$ in. lugs on each of the four edges. This provides a definite and uniform $\frac{1}{4}$ in. joint all round for the full depth of the tile, ensuring a permanent bond and reducing installation costs. Each lug extends for $\frac{1}{4}$ in. along the edge of the tile and occupies the back half of the $\frac{1}{8}$ in. thickness. Originally the lug extended the full thickness of the tile but it was found desirable to grind off the outer half. Today the half-thickness lugs are pressed on in a single operation, made possible by the perfection of an automatic turn-over device attached directly to the tile press. This device became necessary because the lugs had to be pressed to the bottom with the tile moulded in the "bottom-up" position and without turnover, ejected tiles would be subjected to face scratching.

A period of 15 years research is reported to lie behind this, a truly close-tolerance mass-produced tile.

All production is on 100-ton fully automatic presses. Case liners are of specially hardened steel to ensure retention of the 20/1000 in. tolerance set for each lug. Die tolerance is 1/1000 in. in order to hold to a 5/1000 in. tolerance allowed for a specific dimension of tile.

BASIC PRINCIPLES OF GLASS TEMPERING

Glancing through a publication produced by our friends "across the pond" we came across an article which began "Glass is a stronger material than steel!" Having recently pushed the hoe through the cucumber frame we read on, with a somewhat patronising air, only to find the author, Ralph K. Day of the Lilly-Owens-Ford Glass Co., was, in fact, talking sense. He went on to say that the practical strength of glass is limited by the variable weakness of its surface due to incipient fissures present, and that tempering prevents these fissures becoming cracks.

Uniformity of Temper

Tempered glass may be described as intelligently strained glass, i.e. glass with all surfaces cooled in such a manner that they end up in compression balancing the tension forces which must be completely under the surface. The actual tempering operation must involve uniform cooling by some tempering medium such as oil, molten salt or air. Uniformity of temper is more important than the degree since the ultimate resistance of the glass article to mechanical or thermal breakage is governed by the weakest point in the structure. He emphasises the importance of design where sharp curves and variation in thickness call for special care in tempering.

The degree of temper can be set at will by suitable control of quenching intensity. In general the glass surfaces must be heated sufficiently to allow them to stretch and the cooling rate controlled in order to determine the amount of temper finally achieved.

Measurement of Degree

The polariscope will indicate uniformity of temper but is of little use as a measure of degree. For measurement of the latter property the quartz wedge is employed to examine cross sectional specimens cut from the article but it must be remembered that certain structural strains are removed by the sawing out of the specimen section. A good practical check is to break the sample using as little energy as possible (e.g. with a drill). The higher the temper the smaller the pieces. Drop tests have been used but are not completely satisfactory.

The suggestion is made that probably the most satisfactory test is the water-quench. If set below that degree of severity which a well tempered piece will stand, it is a good system of rejection-by-breakage for those items improperly tempered.

VACUUM CONVEYOR FOR POWDER HANDLING

Westinghouse again furnish us with a news item. This time it concerns a pneumatic system for unloading flint, china clay and feldspar at Derry, Pa.

They report five specific advantages:

1. More efficient handling with lower labour cost. The system moves 6-8 ton/hr as compared with previous standard of 2½ ton/hr.

The allowed time per truck has been cut from 25 hr. to 10 hr. and demurrage eliminated.

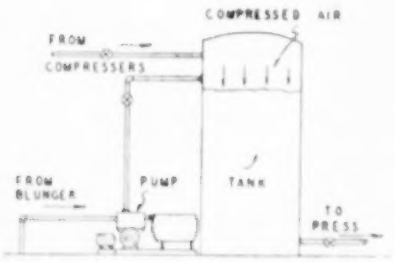
2. Elimination of dust conditions. Respirators have been thus discarded—much to the relief of operatives on hot days!
3. More efficient utilisation of space. The silos enable twice the material to be stored in half the original floor space. At the Derry plant where floor space is valued at £11 per sq. ft. this can be quite a point.
4. Less contamination of material since it is stored in dust-proof, water-proof silos.
5. Improved employee relations! Originally truck-unloading was a dirty job that nobody wanted. The pneumatic system has changed this. Further, pneumatic systems are simple and silent in operation, whilst it was their low installation cost which first caused them to be considered for ceramic handling.

Four silos each 68 ft. high and 14 ft. in diameter are used. An airfilter is installed above the silos to separate the material from the air after its journey via the 6 in. duct from the truck. The only manual labour involved is that of directing the intake nozzle at the material to be handled.

COMPRESSED AIR v SLIP PUMPS

From the Shenango Pottery Co., New Castle, Pa., comes a report on the use of compressed air in supplying filter presses.

The method employs a number of air-tight slip tanks (each of 1,500 gallon capacity). The prepared slip is pumped from blungers into tanks, an operation which takes about 10 min., and is the only pumping required. Moreover, with this arrangement the pump has merely to lift the slip a short distance as opposed to having to deliver against pressure. When a press is ready to be filled, the pump line is closed and the press line opened. Compressed air at 80 lb./sq. in. maximum is introduced to the top of the tank and the slip thus moved speedily and smoothly to the press, filling taking one hour.



Slip tank and pump arrangement

Advantages claimed are:—

1. Reduced wear on pumps.
2. Reduction in filling time at the press.
3. More uniform filter cakes (due to lack of pump pulsations).

DEMAND FOR DECORATED WARE

THERE is ample evidence that the demand for white ware in the home market has been largely met except in the country areas and that demand is now essentially for decorated ware of every type. Speaking on this point recently a Scottish buyer, with national contacts, indicated that white ware sales were diminishing, a view borne out by the revival of mail-order selling, by firms in the Potteries.

In Scotland the demand is for decorated ware, and no amount of display or price cutting is having any real effect in clearing white ware. Stocks have been gradually accumulating in most stores to a point where practically any type of requirement can be met. But there is no real demand, and the essential need is now for the release of some decorated qualities to the home market. Frustrated exports, accumulated and discontinued exports and rejects from reputable firms are helping to make good this shortage.

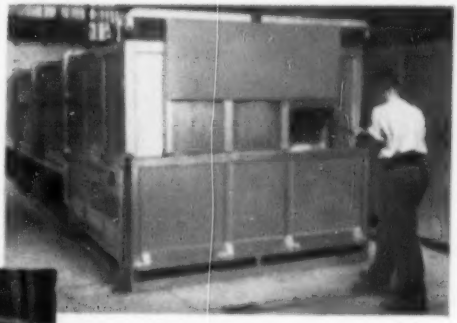
Scottish potteries have contributed to the improved position. Earthenware and stoneware are their main products, however, and it is on these lines that production has been concentrated. The main supplies still come from England, however, and Scottish buyers are maintaining constant touch with the Potteries in anticipation of a change. Any drop in export demand could lead to an adjustment of the home position, and even to a decorated surplus, in due course, similar to the surplus of white ware now being experienced.

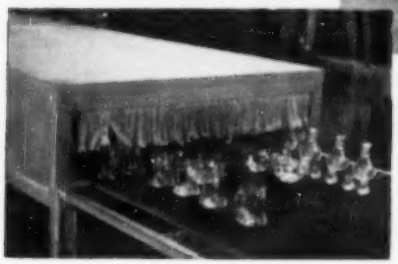
IMPROVED **LEHRS—KILNS** AND **OVENS** BY

WEBCOT LTD.

The lehr shown has a 5 ft. wide conveyor and has been used by Stuart Sons Ltd., Stourbridge, for annealing crystal glassware to a predetermined curve.

For equal placing space, fuel cost is only about half that previously accepted for existing lehrs working under the same conditions.





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BUILDING RESEARCH

Congress to be held in London in 1951

A CONGRESS on building research is to be held in London from 11th to 20th September, 1951, the first of its kind ever to be held. It will mark the rapid developments in building science made since the end of the war, and has been arranged because of the great and growing interest shown in the subject in many countries.

The Congress is sponsored by the British professional institutions and learned societies interested in building science, and by Government departments, with the support of representative industrial federations in Great Britain. The Department of Scientific and Industrial Research is providing the central organisation for the Conference. Papers are being invited from research workers in many countries on a wide range of topics, and arrangements are being made to welcome to the Congress a large number of visitors from overseas.

The purpose of the Congress will be to review the progress made in research in relation to architecture, building and the associated branches of civil engineering.

The scope is indicated by the following representative list of subjects. The papers presented will deal with recent research and its influence on modern development.

The effect of summer and winter conditions on the heating and cooling of buildings; the lighting of buildings; problems of special types of buildings, particularly schools, hospitals and factories; the acoustics of auditoria and broadcasting studios.

Mechanisation of building operations; prefabrication; steelwork design; concrete design; soil mechanics and the design of foundations.

Weathering and durability of building materials in temperate and extreme climates; lightweight concrete; quality control and accelerated curing of concrete; development in manufacture and the structural use of burnt clay products; stone for housing and developments in quarry mechanisation; gypsum products, limes, painting, etc.

The Congress will be organised in three divisions which will hold concurrent meetings. Visits to buildings of interest and to civil engineering works, etc., will be arranged.

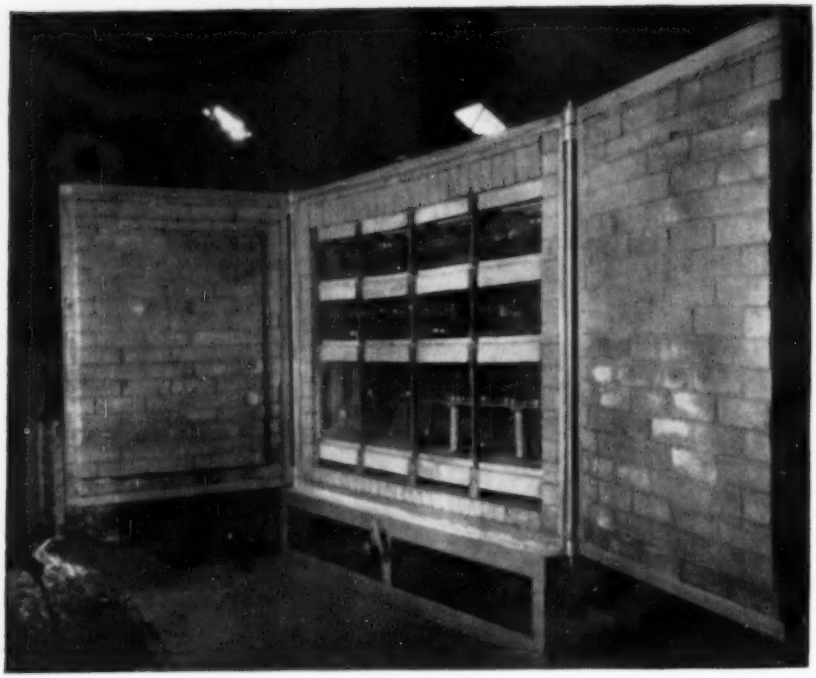


Fig. 1. Illustration showing cell construction of annealing kiln

A Glass Annealing Kiln Installation

by

B. W. E. WEBBER*

OF all the processes in the absorbing craft of glass-making the least known, but most important, is annealing or stress relieving. Breakage in use due to questionable annealing is now rare due to the care and attention given to this subject by the industry. All manufacturers appreciate the value of correct annealing, and none better than Stuart & Sons Ltd., Stourbridge, makers of the famous "Stuart Crystal."

* Director, Webcot Ltd., Bucknall, Stoke-on-Trent.

The installation of a 75 ft. long electric lehr, with 5 ft. wide conveyor, adequately met the problem of annealing the large increase in output of general table and stem ware, but a further difficulty remained in maintaining their high standard of annealing for the many and varied heavy bowls and centrepieces. On completion of the lehr, Webcot Ltd. co-operated in preparing a specification for the installation.

Owing to the number and diversity of pieces treated, the kiln had to be

of the intermittent type with automatic but flexible time-temperature control. An extremely difficult requirement to meet in a muffle of the dimensions suggested was a temperature uniformity during all stages of the cycle to within ±5° C. This will be appreciated by those aquainted with the elementary theory of annealing.

The essential facts of time and temperature must be known for the particular glass and shape to be treated. Generally speaking, the time is increased according to the weight or thickness of the section and the temperature is reduced, within a specified range, according to the complication, or variation in the shape. For the problem under consideration a long soak at a relatively low temperature was required and, as already stressed, it was essential that every piece received the same treatment.

Test Results

To achieve the results required, it was decided to use the construction illustrated in Fig. 1, the overall dimensions of which are 7 ft. 6 in. long by 4 ft. deep by 6 ft. 6 in. high, and the placing capacity 45 c. ft. Heating elements are placed above and below each of the twelve sections or cells in the kiln and no piece of ware is further from a source of heat than its neighbour.

In the tests taken on the kiln in use, a temperature uniformity of ±2° C. was obtained at maximum temperature, the actual figures being illustrated in Fig. 2. In this test thermocouples were placed in the cells at various positions, and a typical example is shown in the key. Thermocouple No. 3 was placed as near to the element wire as possible to indicate the operating temperature.

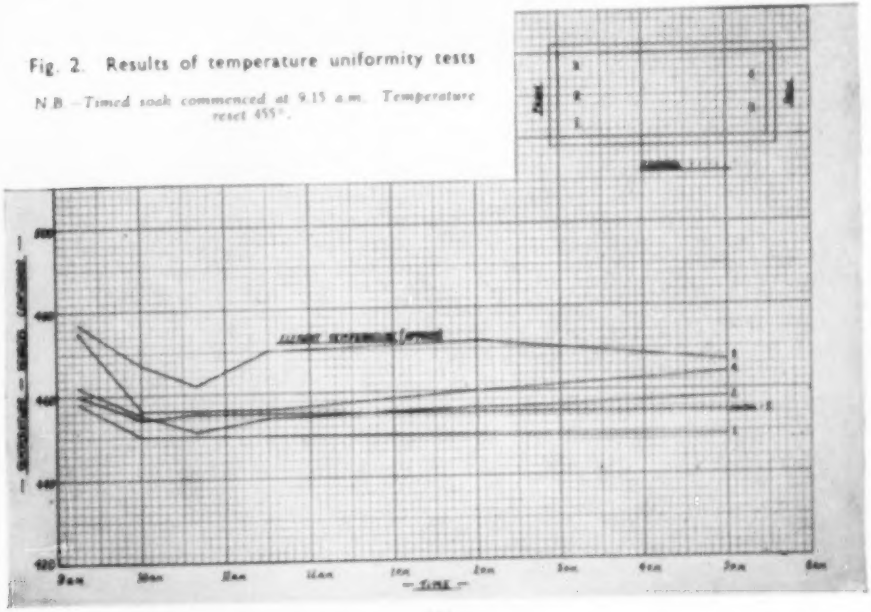
These thermocouples were placed in the bottom right hand cell and it is interesting to note that the temperature recorded by No. 5 'couple was identical with that shown by the controller 'couple placed in the middle centre cell.

With a kiln of this type it is quite possible to obtain a rapid rate of heating if required, without the sharp temperature gradient from heating elements to centre of the kiln inherent in any normal muffle of reasonable size.

Modern lightweight insulating materials are used throughout to reduce heat lost by storage and the cell structure is built up from standard backing tiles, shaped to protect the

Fig. 2. Results of temperature uniformity tests

N.B.—Timed soak commenced at 9.15 a.m. Temperature reset 455°.



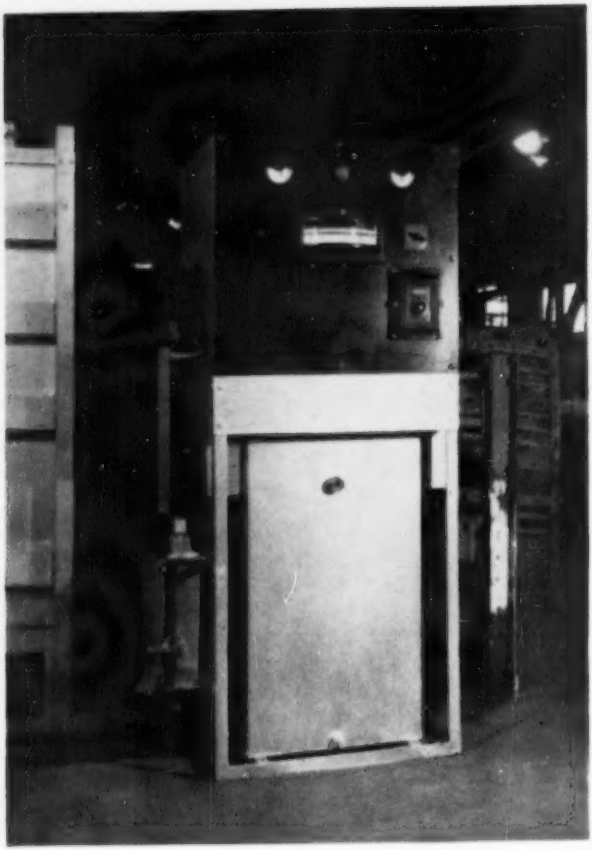


Fig. 3
Showing control panel and transformer of annealing kilns

heaters but to give free radiation of the heat. The tiles are carried on aluminised cast-iron supports, the bases of which form runners for the aluminised perforated trays carrying the ware.

Double swing doors, carried on robust hinges, are faced to provide a seal when clamped up. Heat losses are further reduced by a sand seal along the bottom edge, and a rebate into the muffle faces up to the front edge of the cell tiles.

Heating Elements

Heating elements are wound from heavy gauge nickel chrome wire on high temperature elcetrical porcelain formers. They are fitted into the kiln from each side and are fully protected from accidental damage.

A feature of these elements is that they can be built up to any length within the limits of reasonable handling and are easily replaced from outside the kiln when required. They can be used in the vertical position if desired. Heavy rod leads pass through porcelain tubes in brick plugs and the outer surface, inside the spring-capped terminal boxes, is sealed with pads of high density fibrous insulating material.

Special Clamps

Series connections to the element leads are completed with special heavy connecting clamps and copper strip. All V.I.R. cables feeding the element busbars from the adjacent transformer are enclosed in steel trunking.

In spite of the safety inherent in the design it was preferred that the 200 volt two phase supply be reduced to 50 volts and the wiring is so

arranged that at no point is the potential difference between adjacent elements, or the earth, greater than 50.

Having proved the superiority of mercury relays for continuous running plant it was desirable that they should be included in the new kiln. From the main busbar in the control panel (Fig. 3), the main cables run to the ammeters and relays, the operating coils of which are controlled by an Electroflo automatic temperature regulator. Suitably connected between the controller and the relay coils is a push button reset and timer, for the purpose of controlling the period of soak after the glass reaches the predetermined temperature. After this soak the kiln is automatically switched off and cools ready for unloading. This feature alone has effected considerable saving in labour, apart from the improvements in annealing and handling.

Procedure after Packing

The procedure after packing the kiln is simple as it is only necessary to switch on the temperature regulator, set the timer to the soak required (from 1 to 20 hours) and press the reset button.

If it is desired to run the kiln on an ordinary temperature controlled circuit a switch is provided to short-circuit the timer. A similar switch is included on the panel to feed the temperature regulator and thus the whole kiln and the accessories are all protected by Slydlock fuses.

Use for Enamelling Glassware

Excellent results are being obtained with the kiln which has amply justified the thought and planning undertaken in the original specification. As adequate ventilation is provided there is no reason why it should not give equally good results if used for enamelling glassware, for the design lends itself very well to this process.

Underfed Stoker.—At the recent Building Exhibition in Manchester and also to be shown at the B.I.F. is the Underfed Automatic Stoker, manufactured by the Mirrlees Watson Co. Ltd., Kennerley Works, Stockport. It will be recalled that this equipment was described recently in CERAMICS.

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Silicate glass on its way to the dissolving plant

Commercial Sodium Silicates

Their Manufacture and Properties

Based on information provided by Joseph Crossfield & Sons Ltd., Warrington

SOLUBLE silicates which consist of sodium oxide and silica bound together in various ratios may be manufactured in several ways, both wet and dry. The dry method is by far the most important and most economical. No wet process up to the present time has achieved industrial importance, with the possible exception of the electrolytic method for the production of high ratio silicates.

Dry methods are limited to materials of greater purity than wet methods. The presence of impurities such as the alkaline earths precludes solution of the fused silicates, and when 5 per cent. or more are present solution becomes practically impossible. Various sodium and potassium salts may be used for the preparation of silicates.

Examples are sodium nitrate, sodium chloride (salt), sodium sulphate, sodium and potassium carbonates, and sodium and potassium hydroxide. Of these, by far the most important are the carbonates which

are available in a high state of purity, react at reasonable furnace temperatures and do not produce offensive and troublesome by-products.

Dry Method of Manufacture

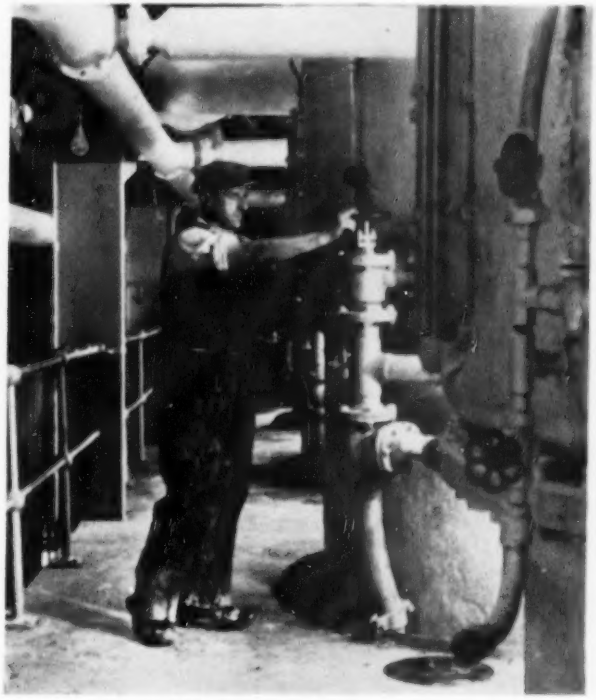
Soluble silicates are made on an industrial scale by fusing together, in a furnace, sand and sodium carbonate. The purity of the sand is approximately 99 per cent. silica. The furnaces are usually open hearth regenerative furnaces, but reverbatory furnaces of another type are also used. Oil or producer gas is the usual fuel and the temperature of operation lies between 1,300° C. and 1,500° C. which is sufficient to drive off most of the sodium chloride impurity. The fused glass may be tapped continuously from the furnaces, being carried away on a cooled bucket conveyor.

Batch tapping is also used, in which case the glass is allowed to cool before being removed to storage. When the glass has cooled it may be sold as glass, powdered glass, or converted to soluble powders, and solutions.

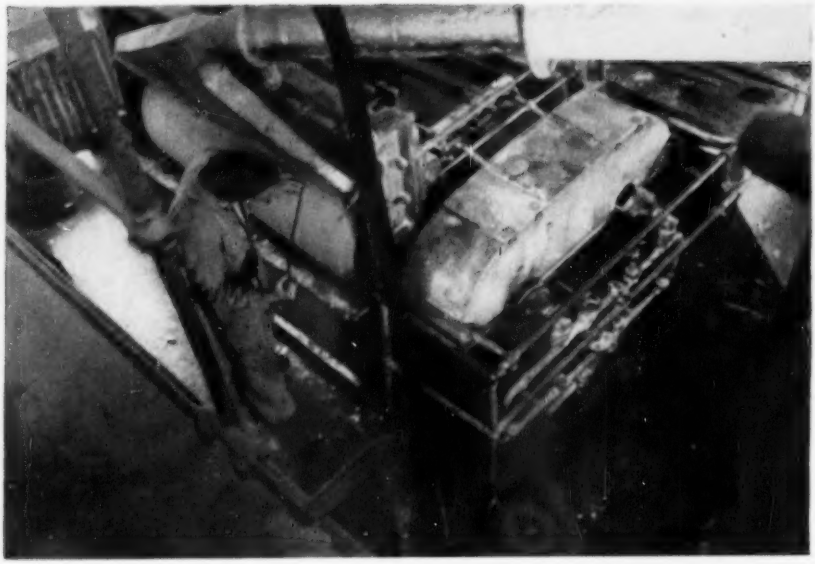
To get the glass into solution special types of dissolver are required the glass having to be in excess to prevent decomposition. The use of steam greatly assists solution by forming a resilient layer (containing water) on the glass and this is easily soluble in hot water. Two types of dissolver are used, a vertical stationary dissolver and a horizontal rotary dissolver.

In the case of the vertical stationary dissolver the entire chamber is filled with relatively coarse glass which is covered with water and steam is passed in. Heat is applied by closed steam coils and a check is kept on the solution so that it may be run out at the right specific gravity. If it is allowed to get too viscous, solidification may occur.

After the dissolver has been discharged it may be recharged with water and a fresh batch of solution made. In the case of the rotary horizontal dissolver the glass lies in the bottom, while the rotation pro-



The vacuum evaporators for the concentration of silicate solutions



One stage in the manufacture of sodium silicate soluble powder

vides the liquor with sufficient agitation to dilute the strong liquor in the bottom sufficiently to prevent solidification. In both cases an excess of solid is used.

After dissolving, the solutions are clarified by settling or filtration and are then evaporated to the required concentration. The solutions are stored in cast-iron tanks and dispatched by rail tank, road tank or in drums.

Glass in lump form is transported in closed railway trucks or in jute sacks. Powdered glass and soluble powder should be stored and transported in air tight metal containers. Wooden barrels are not normally used, as moisture penetration through the wood may lead to powdered silicates caking and silicate solutions becoming too viscous. Metal drums, tanks and tank cars are preferred. Galvanized metal should not be used, as the silicate reacts with zinc, releasing hydrogen which will eventually burst the drum. Tin cans may be used for storage of the more silicious grades above 38 per cent., but alkaline silicates below 55 per cent. cause some solution of the metal. Solutions more alkaline will attack solder and cause leaks.

Silicate solutions may usually be pumped quite easily by rotary or centrifugal pumps, except in the case of the more viscous grades, particularly under cold conditions, where a positive displacement pump may be required. Precautions should consist of keeping stuffing boxes tight by saturating with mineral oil and graphite free from grease and saponifiable materials and, where necessary, a water gland should be applied. Tank cars may be emptied by pumping, by air pressure, or by gravity flow.

General Properties

Sodium silicates consist of sodium oxide Na_2O and silica SiO_2, combined together in various ratios, sometimes expressed as molecular ratios, sometimes as weight ratios. Thus the formula $Na_2O : 2SiO_2$ may mean that there is one molecule of Na_2O to two molecules of silica. It can also mean that there is twice the weight of SiO_2 to Na_2O. The ratio is usually

found by chemical analysis, the amounts of Na_2O and SiO_2 being found separately.

In composition the sodium silicates fall into two broad classes, the so called "Alkaline" and "Neutral" grades. The former have Na_2O : SiO_2 ratios of 1 : 2 and the latter ratios of 1 : 3·3 or more. Both forms exhibit an alkaline reaction in solution but the "Neutral" silicates are much less alkaline than the "Alkaline" silicates.

It is of course possible to make silicates with ratios lower than 2·0, between 2·0 and 3·3, and higher than 3·3. Above a ratio of 1 : 3·65 silicate solutions become unstable and tend to form gels due to silicic acid separating out. Below a ratio of 1 : 1·65 are the crystalline metasilicate and sesquisilicate which have quite different properties from the ordinary sodium silicates.

To convert molecular ratio to weight ratio multiply by 60/62. Thus if Na_2O. 3·3 SiO_2 is written as a molecular ratio, the weight ratio will be Na_2O. 3·2 SiO_2. When a high ratio silicate is mentioned a high silica content is implied.

The Specific Gravity (S.G.) is normally indicated on the Twaddell (Tw.) or Beaumé (Bé) hydrometer scales.

Specific Gravity can be converted to ° Twaddell or ° Beaumé and vice versa by using the following formulæ:

(i) To convert Specific Gravity to ° Twaddell.

$$^\circ \text{Tw.} = 200 \times (\text{S.G.} - 1)$$

(ii) To convert ° Twaddell to Specific Gravity.

$$\text{Specific Gravity} = 1 + (^\circ \text{Tw.} \div 200)$$

(iii) To convert Specific Gravity to ° Beaumé.

$$^\circ \text{Beaumé} = 145 - \frac{145}{\text{S.G.}}$$

(iv) To convert ° Beaumé to Specific Gravity.

$$\text{Specific Gravity} = \frac{(145 - {}^\circ \text{Bé})}{145}$$

When measuring the specific gravity a hydrometer is used. This should be clean and dry and should be placed in the silicate and allowed to sink of its own accord. Care should be taken that no surface skin is

Modern open hearth regenerative silicate furnace using cooled bucket continuous method of tapping

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present when the specific gravity is measured, as this will prevent the hydrometer sinking, resulting in a high specific gravity reading. Specific gravity varies with temperature and thus a standard temperature should be used for accuracy.

Another important property of the solutions is their viscosity. For the same total solids concentration the viscosity will be higher in solutions of higher silica to soda ratio. The viscosity of the more silicious silicates increases rapidly with concentration while the more alkaline silicates show a more gradual increase.

The viscosity of silicate solutions varies from one grade to another, some being like thick treacle at room temperatures and others resembling water. The viscosity varies with temperature quite substantially and care should be taken to use a standard temperature when measuring the viscosity of any silicate solution. The viscosity is usually measured by finding the time taken for a steel sphere to fall a certain distance through the liquid. The time is related to the viscosity which is measured in centipoises. (The viscosity of distilled water at 20° C. being 1 centipoise.)

At low temperatures concentrated solutions behave as super-cooled liquids and become brittle and glass-like. Dilute solutions, however, may be frozen. At low temperatures ice crystals separate and rise to the surface. A solution of 1 : 3·3 ratio silicate containing 38 per cent. total solids freezes at 28° F. and separates, while a 54 per cent. solution of 1 : 2 ratio silicate remains clear far below 0° F. By warming and agitation the solutions may be brought back to their normal consistency and show no change in properties. In general the tackiness of a silicate solution decreases as the silica ratio increases and it also decreases with temperature. Tackiness increases with concentration and viscosity.

Solid Forms of Sodium Silicate

Alkaline and neutral glass can be dissolved to make up solutions.

Powdered glass is also available for certain uses, usually to be used in solid form.

Soluble powders are specially prepared solid silicates which are readily soluble in cold or hot water at ordinary pressure. They do not however represent an economic method of buying glass for re-dissolving on an industrial scale, but are more suitable for small scale operations.

This is an Arrow Press Publication. Published Monthly.
Subscription Rate 25s. per annum.
Published by Arrow Press Ltd. at 29, Grove Road, Leighton Buzzard, Beds
Telegrams: Gastymes, Leighton Buzzard. Telephone: Leighton Buzzard 2328/9.

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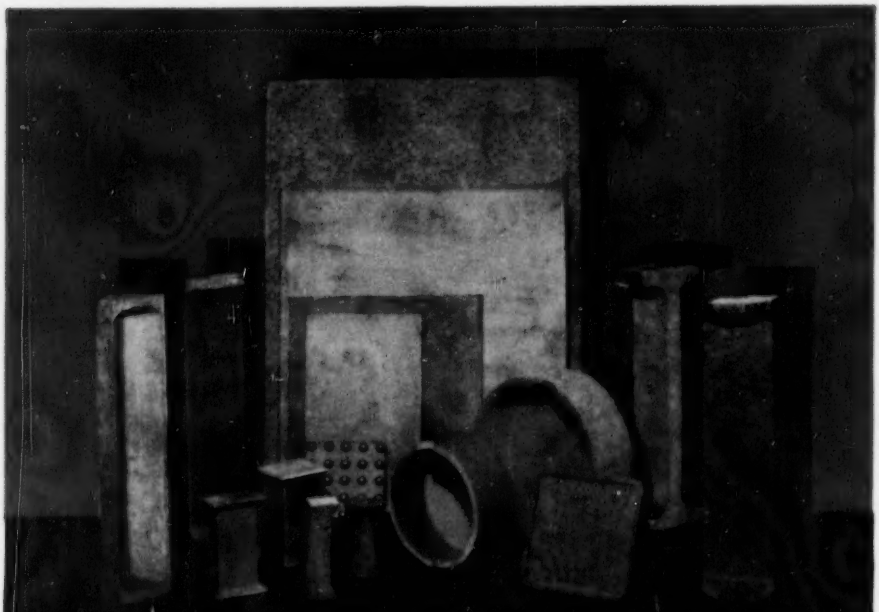

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